INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/12537

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B32B 7/12
US CL :428/343,352

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 428/343,352

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WEST
search terms: adhesive, tape, insulating, EMI, reinforcing, layer, release, liner, agent,

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 5,858,490 A (MORI et al) 12 January 1999, see entire document.	1-14 --- 15-18
A	US 4,868,035 A (WEINBERG et al) 19 September 1989, see entire document.	1-18

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 03 JULY 2000	Date of mailing of the international search report 14 AUG 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer JULA C. RUDDOCK Telephone No. (703) 308-0661

Form PCT/ISA/210 (second sheet) (July 1998)★

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* ASTP0005PCT

Box No. I TITLE OF INVENTION

SEQUENCE NUMBER ORDERING IN A WIRELESS COMMUNICATIONS SYSTEM

Box No. II APPLICANT ☐ This person is also inventor

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

ASUSTeK COMPUTER INC.
4F, No.150, Li-Te Rd., Peitou,
Taipei City, Taiwan, R.O.C.

Telephone No. +886-2-2894-3447

Facsimile No.

Teleprinter No.

Applicant's registration No. with the Office

State *(that is, country)* of nationality: Republic of China

State *(that is, country)* of residence: Republic of China

This person is applicant for the purposes of: ☒ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

ASUS COMPUTER INTERNATIONAL
6737 Mowry Ave., Mowry Business Center,
Building 2 Newark, CA 94560, U.S.A.

This person is:
☒ applicant only
☐ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality: United States of America

State *(that is, country)* of residence: United States of America

This person is applicant for the purposes of: ☒ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

Winston Hsu,
5F, No.389, Fu-Ho Rd.,
234 Yungho City, Taipei Hsien,
Taiwan, R.O.C.

Telephone No. +886-2-8923-7350

Facsimile No. +886-2-8923-7390

Teleprinter No.

Agent's registration No. with the Office 41,526

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

Sam Shiaw-Shiang Jiang
No.25, Alley 23, Lane 473, Nan-Ta Rd.,
Hsin-Chu City, Taiwan, R.O.C.

This person is:

- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality: Republic of China

State *(that is, country)* of residence: Republic of China

This person is applicant for the purposes of: ☒ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:

- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:

- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:

- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES *Mark the applicable check-boxes below; at least one must be marked.*

The following designations are hereby made under Rule 4.9(a):

Regional Patent

☐ **AP** **ARIPO Patent:** **GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **MZ** Mozambique, **SD** Sudan, **SL** Sierra Leone, **SZ** Swaziland, **TZ** United Republic of Tanzania, **UG** Uganda, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

☐ **EA** **Eurasian Patent:** **AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakhstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☒ **EP** **European Patent:** **AT** Austria, **BE** Belgium, **CH & LI** Switzerland and Liechtenstein, **CY** Cyprus, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **SE** Sweden, **TR** Turkey, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☐ **OA** **OAPI Patent:** **BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Côte d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **GW** Guinea-Bissau, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

☐ **AE** United Arab Emirates
☐ **AG** Antigua and Barbuda
☐ **AL** Albania
☐ **AM** Armenia
☐ **AT** Austria
☐ **AU** Australia
☐ **AZ** Azerbaijan
☐ **BA** Bosnia and Herzegovina
☐ **BB** Barbados
☐ **BG** Bulgaria
☐ **BR** Brazil
☐ **BY** Belarus
☐ **BZ** Belize
☐ **CA** Canada
☐ **CH & LI** Switzerland and Liechtenstein
☒ **CN** China
☐ **CO** Colombia
☐ **CR** Costa Rica
☐ **CU** Cuba
☐ **CZ** Czech Republic
☒ **DE** Germany
☐ **DK** Denmark
☐ **DM** Dominica
☐ **DZ** Algeria
☐ **EE** Estonia
☐ **ES** Spain
☒ **FI** Finland
☒ **GB** United Kingdom
☐ **GD** Grenada
☐ **GE** Georgia
☐ **GH** Ghana
☐ **GM** Gambia
☐ **HR** Croatia
☐ **HU** Hungary
☐ **ID** Indonesia
☐ **IL** Israel
☐ **IN** India
☐ **IS** Iceland
☒ **JP** Japan
☐ **KE** Kenya
☐ **KG** Kyrgyzstan
☐ **KP** Democratic People's Republic of Korea
☒ **KR** Republic of Korea
☐ **KZ** Kazakhstan
☐ **LC** Saint Lucia
☐ **LK** Sri Lanka
☐ **LR** Liberia
☐ **LS** Lesotho
☐ **LT** Lithuania
☐ **LU** Luxembourg
☐ **LV** Latvia
☐ **MA** Morocco
☐ **MD** Republic of Moldova
☐ **MG** Madagascar
☐ **MK** The former Yugoslav Republic of Macedonia
☐ **MN** Mongolia
☐ **MW** Malawi
☐ **MX** Mexico
☐ **MZ** Mozambique
☐ **NO** Norway
☐ **NZ** New Zealand
☐ **PL** Poland
☐ **PT** Portugal
☐ **RO** Romania
☐ **RU** Russian Federation
☐ **SD** Sudan
☒ **SE** Sweden
☐ **SG** Singapore
☐ **SI** Slovenia
☐ **SK** Slovakia
☐ **SL** Sierra Leone
☐ **TJ** Tajikistan
☐ **TM** Turkmenistan
☐ **TR** Turkey
☐ **TT** Trinidad and Tobago
☐ **TZ** United Republic of Tanzania
☐ **UA** Ukraine
☐ **UG** Uganda
☐ **US** United States of America
☐ **UZ** Uzbekistan
☐ **VN** Viet Nam
☐ **YU** Yugoslavia
☐ **ZA** South Africa
☐ **ZW** Zimbabwe

Check-boxes below reserved for designating States which have become party to the PCT after issuance of this sheet:

☐ ..... ☐ ..... ☐ .....
☐ ..... ☐ ..... ☐ .....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)*

Box No. VI PRIORITY CLAIM

The priority of the following earlier application(s) is hereby claimed:

Filing date of earlier application *(day/month/year)*	Number of earlier application	Where earlier application is:		
		national application: country	regional application:* regional Office	international application: receiving Office
item (1) 10/01/2001	09/756,737	USA		
item (2)				
item (3)				
item (4)				
item (5)				

☐ Further priority claims are indicated in the Supplemental Box.

The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of this international application is the receiving Office)* identified above as:

☐ all items ☐ item (1) ☐ item (2) ☐ item (3) ☐ item (4) ☐ item (5) ☐ other, see Supplemental Box

** Where the earlier application is an ARIPO application, indicate at least one country party to the Paris Convention for the Protection of Industrial Property or one Member of the World Trade Organization for which that earlier application was filed (Rule 4.10(b)(ii)):* ....

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)*:

ISA / US

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority)*:

Date *(day/month/year)* Number Country *(or regional Office)*

Box No. VIII DECLARATIONS

The following **declarations** are contained in Boxes Nos. VIII (i) to (v) *(mark the applicable check-boxes below and indicate in the right column the number of each type of declaration)*: Number of declarations

☐	Box No. VIII (i)	Declaration as to the identity of the inventor	:
☐	Box No. VIII (ii)	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	:
☐	Box No. VIII (iii)	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	:
☐	Box No. VIII (iv)	Declaration of inventorship (only for the purposes of the designation of the United States of America)	:
☐	Box No. VIII (v)	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	:

Box No. IX CHECK LIST; LANGUAGE OF FILING

This international application **contains**:

(a) the following number of **sheets in paper form**:

request (including declaration sheets)	:	7
description (excluding sequence listing part)	:	18
claims	:	3
abstract	:	1
drawings	:	18
Sub-total number of sheets	:	47
sequence listing part of description *(actual number of sheets if filed in paper form, whether or not also filed in computer readable form; see (b) below)*	:	0
Total number of sheets	:	47

(b) sequence listing part of description filed in **computer readable form**

(i) ☐ only (under Section 801(a)(i))

(ii) ☐ in addition to being filed in paper form (under Section 801(a)(ii))

Type and number of carriers (diskette, CD-ROM, CD-R or other) on which the sequence listing part is contained *(additional copies to be indicated under item 9(ii), in right column)*: .....

This international application is **accompanied by** the following item(s) *(mark the applicable check-boxes below and indicate in right column the number of each item)*:

		Number of items
1. ☒ fee calculation sheet	:	1
2. ☒ original separate power of attorney	:	1
3. ☐ original general power of attorney	:	
4. ☐ copy of general power of attorney; reference number, if any:	:	
5. ☐ statement explaining lack of signature	:	
6. ☒ priority document(s) identified in Box No. VI as item(s): (1)	:	
7. ☐ translation of international application into *(language)*:	:	
8. ☐ separate indications concerning deposited microorganism or other biological material	:	
9. ☐ sequence listing in computer readable form (indicate also type and number of carriers (diskette, CD-ROM, CD-R or other))		
(i) ☐ copy submitted for the purposes of international search under Rule 13*ter* only (and not as part of the international application)	:	
(ii) ☐ *(only where check-box (b)(i) or (b)(ii) is marked in left column)* additional copies including, where applicable, the copy for the purposes of international search under Rule 13*ter*	:	
(iii) ☐ together with relevant statement as to the identity of the copy or copies with the sequence listing part mentioned in left column	:	
10. ☒ other *(specify)*: declaration, assignment papers	:	

Figure of the drawings which should accompany the abstract:

Language of filing of the international application: English

Box No. X SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

Winston Hsu 4/2/2002

Winston Hsu, Paten Agent
Reg. No. : 41,526

For receiving Office use only

1. Date of actual receipt of the purported international application:

2. Drawings:
☐ received:
☐ not received:

3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:

4. Date of timely receipt of the required corrections under PCT Article 11(2):

5. International Searching Authority (if two or more are competent): ISA /

6. ☐ Transmittal of search copy delayed until search fee is paid

For International Bureau use only

Date of receipt of the record copy by the International Bureau: .

PATENT
Docket No. ASTP0005PCT

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

I believe I am the sole (if only one name appears below), or a joint (if more than one name appears), original and first inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:
" Sequence number ordering in a wireless communications system "

\+ The specification for the above entitled invention is filed herewith.

_____ The specification for the above entitled invention was filed previously with application serial number: _____ Filing Date: _____

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of the invention disclosed in this application in accordance with Title 37, Code of Federal Regulations, Section 1.56 (a). I further acknowledge the duty in any continuation-in-part application to disclose to the Patent and Trademark Office all information known to be material to the patentability of the invention disclosed in this application, as defined in 1.56, which became available to me between the filing date of the prior application and the filing date of this application.

PRIORITY CLAIM

_____ There is no claim of priority.

\+ Claim of priority is based on the following:

Filing No. in U.S.A.: 09/756,737

Filing Date in U.S.A.: 2001/01/10

POWER OF ATTORNEY

As a named inventor, I hereby appoint the following attorney to prosecute this application and to transact all related business in the Patent and Trademark Office:

Winston Hsu, Registration Number 41,526
5F, No.389, Fu-Ho Rd., YUNGHO City,
Taipei Hsien, Taiwan, R.O.C.
TEL: +886-2-8923-7350

DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false stat ments may jeopardize the validity of the application or any patent issued hereon.

Date: Dec. 26, 2001 Sam Shiaw-Shiang Jiang

Printed Name: Sam Shiaw-Shiang Jiang
Post Office Address: No.25, Alley 23, Lane 473, Nan-Ta Rd.,
and Residence: Hsin-Chu City, Taiwan, R.O.C.
Citizen of: R.O.C.

Date: _____

Printed Name: _____
Post Office Address: _____
and Residence: _____
Citizen of: _____

Date: _____

Printed Name: _____
Post Office Address: _____
and Residence: _____
Citizen of: _____

Date: _____

Printed Name: _____
Post Office Address: _____
and Residence: _____
Citizen of: _____

Date: _____

Printed Name: _____
Post Office Address: _____
and Residence: _____
Citizen of: _____

PATENT
Docket No.: ASTP0005PCT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

RECORDING COVER SHEET

1. Assignor: Sam Shiaw-Shiang Jiang
2. Assignee: 1) ASUSTeK COMPUTER INC.
   4F, No. 150, Li-Te Rd., Peitou, Taipei City,
   Taiwan, R.O.C.
   2) ASUS COMPUTER INTERNATIONAL
   6737 Mowry Ave., Mowry Business Center,
   Building 2 Newark, CA 94560, U.S.A.
3. Nature of Conveyance: Assignment of patent
4. Reference number: Application filed herewith.
5. Correspondence to: Winston Hsu
   5F, No. 389, Fu-Ho Rd.,
   234 YungHo City, Taipei Hsien,
   Taiwan, R.O.C.
6. Number of applications affected by this recording: 1
   Total fee: (1x $ 40) = $ 40.00
   Authorization is hereby given to charge the over payment to deposit account #500801
7. Execution date of the document to be recorded: 12/26/2001
8. Total number of pages including cover sheet: 2
9. I declare under penalty of perjury that to the best of my knowledge and belief, the information contained on this cover sheet is true and correct, and that any copy submitted herewith is a true and correct copy of the original document.

Date: 1/2/2002 Winston Hsu

Winston Hsu
U.S. Patent Agent
Reg. No.:41,526

PATENT

Docket No. ASTP0005PCT

ASSIGNMENT OF INVENTION

(Assignor Name) Sam Shiaw-Shiang Jiang , (Address) No.25, Alley 23, Lane 473, Nan-Ta Rd., Hsin-Chu City, Taiwan, R.O.C., have invented a device called " Sequence number ordering in a wireless communications system "

(Assignee name) (1) ASUSTeK COMPUTER INC. , and
(2) ASUS COMPUTER INTERNATIONAL ,

(hereinafter "Assignee"), of (Assignee address) (1) 4F, No.150, Li-Te Rd., Peitou, Taipei City, Taiwan, R.O.C. and (2) 6737 Mowry Ave. Mowry Business Center, Building 2 Newark, CA 94560, USA , wishes to acquire the entire right, title, and interest in and to the invention and to any letters patent that may be granted therefor in the United States and in any and all foreign countries.

Accordingly, in consideration of the sum of One Dollar, ($1.00) to me in hand paid, the receipt of which is hereby acknowledged, and other good and valuable consideration, Assignor, hereby sells, assigns, and transfers to Assignee the full and exclusive right to the above described invention in the United States and its territorial possessions, and in all foreign countries. The rights granted include the entire right, title, and interest in and to any and all letters patent which may be granted on the invention, including any rights gained by divisions, reissues, continuations, and extensions of the above described application.

I hereby authorize and request the Patent and Trademark Office Officials in the United States and any and all foreign countries to issue any and all letters patent, when issued, to Assignee, as the assignee of my entire right, title, and interest in and to the invention, for the sole use and enjoyment of Assignee and its successors and assignees.

Further, I agree that I will communicate to Assignee or its representatives any facts known to me respecting the invention, to testify in any legal proceedings, to sign all lawful papers, to execute all divisions, continuations, substitutions, renewal and reissue applications, and to generally do those things necessary to aid Assignee and its successors and assigns to obtain and enforce proper protection for the invention in the United States and in any and all foreign countries.

Date: Dec 26, 2001 , Sam Shiaw-Shiang Jiang (Assignor signature)

Sam Shiaw-Shiang Jiang (Print Assignor's name)

This sheet is not part of and does not count as a sheet of the international application.

PCT

FEE CALCULATION SHEET

Annex to the Request

For receiving Office use only

International Application No.

Date stamp of the receiving Office

Applicant's or agent's file reference: ASTP0005PCT

Applicant: ASUSTeK COMPUTER INC, ASUS COMPUTER INTERNATIONAL, Sam Shiaw-Shiang Jiang

CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE . . . . . 240 [T]

2. SEARCH FEE . . . . . 450 [S]

International search to be carried out by US

(If two or more International Searching Authorities are competent to carry out the international search, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FEE

Basic Fee

Where item (b) of Box No. IX applies, enter **Sub-total number of sheets**
Where item (b) of Box No. IX does not apply, enter **Total number of sheets** } 47

[b1] first 30 sheets . . . . . 382 [b1]

[b2] 17 (number of sheets in excess of 30) x 9 (fee per sheet) = 153 [b2]

[b3] additional component (only if sequence listing part of description is filed in computer readable form under Section 801(a)(i), or both in that form and on paper, under Section 801(a)(ii)):

400 x _____ (fee per sheet) = 0 [b3]

Add amounts entered at b1, b2 and b3 and enter total at B . . . . 535 [B]

Designation Fees

The international application contains 6 designations.

6 (number of designation fees payable *(maximum 6)*) x 82 (amount of designation fee) = 492 [D]

Add amounts entered at B and D and enter total at I . . . . . 1027 [I]

(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 25% of the sum of the amounts entered at B and D.)

4. FEE FOR PRIORITY DOCUMENT *(if applicable)* . . . . . 0 [P]

5. TOTAL FEES PAYABLE . . . . . 1717 TOTAL

Add amounts entered at T, S, I and P, and enter total in the TOTAL box

☐ The designation fees are not paid at this time.

MODE OF PAYMENT

☒ authorization to charge deposit account (see below) ☐ postal money order ☐ cash ☐ coupons

☐ cheque ☐ bank draft ☐ revenue stamps ☐ other *(specify):*

AUTHORIZATION TO CHARGE (OR CREDIT) DEPOSIT ACCOUNT

(This mode of payment may not be available at all receiving Offices)

Receiving Office: RO/ US

Deposit Account No.: 50-0801

Date: 1/2/2002

Name: Winston Hsu

Signature: Winston Hsu

☒ Authorization to charge the total fees indicated above.

☒ *(This check-box may be marked only if the conditions for deposit accounts of the receiving Office so permit)* Authorization to charge any deficiency or credit any overpayment in the total fees indicated above.

☐ Authorization to charge the fee for priority document.

SEQUENCE NUMBER ORDERING IN A WIRELESS COMMUNICATIONS SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a wireless communications system. More specifically, the present invention discloses a method and system that can properly determine sequence number ordering when performing an SDU discard procedure with a move receiving window (MRW) operation.

2. Description of the Prior Art

The surge in public demand for wireless communication devices has placed pressure upon industry to develop increasingly sophisticated communications standards. An example of such a standard is the 3rd Generation Partnership Project (3GPP™), Technical Specification Group Radio Access Network, RLC Protocol Specification. Such standards utilize a three layer approach to communications. Please refer to Fig.1. Fig.1 is a block diagram of the three layers in a communications protocol. In a typical wireless environment, a base station 10 is in wireless communications with one or more mobile units 20. An application 13 on the base station 10 composes a message 11 and has it delivered to the mobile unit 20 by handing the message 11 to a layer 3 interface 12. The layer 3 interface 12 delivers the message 11 to a layer 2 interface 16 in the form of layer 2 service data units (SDUs) 14. The layer 2 SDUs 14 may be of any length. The layer 2 interface 16 composes the layer 2 SDUs 14 into one or more layer 2 protocol data units (PDUs) 18. Each layer 2 PDU 18 is of a fixed length, and is delivered to a layer 1 interface 19. The layer 1 interface 19 is the physical layer, transmitting data to the mobile unit

20. The transmitted data is received by the mobile unit 20 by the layer 1 interface 29 and reconstructed into one or more layer 2 PDUs 28, which are passed up to the layer 2 interface 26. The layer 2 interface 26 receives the layer 2 PDUs 28 and builds up a layer 2 SDU 24. The layer 2 SDU 24 is passed up to the layer 3 interface 22. The layer 3 interface 22 in turn converts the layer 2 SDUs 24 (which may also be termed layer 3 PDUs) back into a message 21, which should be identical to the original message 11 that was generated by the base station 10 application 13. The message 21 is then passed to an application 23 on the mobile unit 20.

Of particular interest is the layer 2 interface, which acts as a buffer between the relatively high-end data transmission and reception requests of the applications, and the low-level requirements of the physical transmission and reception process. Please refer to Fig.2. Fig.2 is a diagram of a transmission/reception process from a layer 2 perspective. The layer 2 interface 32 of a transmitter 30, which may be either a base station or a mobile unit, receives a string of layer 2 SDUs 34 from layer 3. The layer 2 SDUs 34 are sequentially ordered from 1 to 5, and are of an unequal length. The layer 2 interface 32 converts the string of layer 2 SDUs 34 into a string of layer 2 PDUs 36. The layer 2 PDUs are sequentially ordered from 1 to 4, and are all of an equal length. The string of layer 2 PDUs is then sent off to the layer 1 interface for transmission. A reverse process occurs at the receiver end 40, with the receiver layer 2 interface 42 converting a received string of layer 2 PDUs 46 into a received string of layer 2 SDUs 44. Under certain transport modes, however, the multi-layered protocol insists that the receiver layer 2 interface 42 present the layer 2 SDUs to layer 3 in order.

That is, the layer 2 interface 42 must present the SDUs 44 to layer 3 in the sequential order of the SDUs 44, beginning with SDU 1 and ending with SDU 5. The ordering of the SDUs 44 may not be scrambled, nor may a subsequent SDU be delivered to layer 3 until all of the prior SDUs have been delivered.

In line transmissions, such a requirement is relatively easy to fulfill. In the noisy environment of wireless transmissions, however, the receiver 40, be it a base station or a mobile unit, often misses data. Some layer 2 PDUs in the received string of PDUs 46 will therefore be missing. Thus, ensuring that the layer 2 SDUs 44 are presented in order can pose a significant challenge. Please refer to Fig.3. Fig.3 is a block diagram of a data PDU 50, as defined in the 3GPP™ TS 25.322 specification. In general, there are two types of PDUs: a control PDU or a data PDU. Control PDUs are used by layer 2 to control data transmission and reception protocols. Data PDUs are used to transmit acknowledged mode data, which is then reassembled and presented to layer 3. The example PDU 50 is a data PDU, and is divided into several fields, as defined by the layer 2 protocol. The first field 51 is a single bit indicating that the PDU 50 is either a data or a control PDU. As the data/control bit 51 is set (i.e., equal to 1), the PDU 50 is marked as an acknowledged mode data PDU. The second field 52 is a sequence number (SN) field, and is twelve bits long. Successive PDUs have successively higher sequence numbers, and in this way a receiver can properly reassembled layer 2 PDUs to form layer 2 SDUs. That is, if a first PDU is transmitted with an SN equal to 536, the next PDU would be transmitted with an SN equal to 537, and so forth. A single polling bit 53 follows the SN field 52, and when set indicates that the receiver should respond with an acknowledgment status PDU,

which is one kind of control PDU, and which will be introduced later. Bit 54 is reserved and is set to zero. The next bit 55a is an extension bit, and when set indicates the presence of a following length indicator (LI). An LI may be either 7 bits long or 15 bits long, and is used to indicate the ending position of a layer 2 SDU within the layer 2 PDU. If a single SDU completely fills the data region 58 of the PDU 50, then the bit 55a would be zero, thereby indicating that no LI is present. In the example PDU 50, however, there are two layer 2 SDUs ending in the layer 2 PDU 50: SDU1 57a and SDU2 57b. There must, therefore, be two LIs to indicate the respective ends of the SDU1 57a and the SDU2 57b. A PDU following the PDU 50 would hold the LI for SDU3 57c. The first LI, LI1, is in field 56a following the extension bit field 55a, and marks the end of the SDU1 57a. LI1 56a has an extension bit 55b that is set, indicating the presence of another LI, LI2 in field 56b. LI2 56b indicates the ending position of the SDU2 57b, and has an extension bit 55c that is cleared, signifying that there are no more LIs, and that the data region 58 is thus beginning.

The fact that the SN field 52 has a fixed bit length presents the peculiar fact that it is possible for layer 2 PDUs having higher SN values to be sequentially before layer 2 PDUs having lower SN values. To better understand this, please refer to Fig.4. Fig.4 is a phase diagram 60 of a sequence number transmission cycle. SN values behave very much like time values on a clock, due to overflow of the 12 bits in the SN field 52. For example, an initial PDU may have an SN value of 0 (shown at position 66), followed by a PDU with an SN=1 (at position 61), and another with an SN=2, etc. The PDU SN values continue incrementing with each PDU, passing the 1024 mark at position

62, the 2048 mark at position 63, the 3072 mark at position 64 and finally reaching a maximum value of 4095 at position 65. At 4095, the SN overflows when incremented, and returns to zero, just as 23:00 hours overflows to 0:00 hours at midnight. Thus, a layer 2 PDU with an SN=2 might be sequentially before a layer 2 PDU with an SN=1000, and yet sequentially after a layer 2 PDU with an SN=4092. If great care is not taken, this inequality of PDU sequentiality with SN numerical ascendancy can lead to confusion.

In the following discussion, receivers and transmitters may be either base stations or a mobile units. The term PDU is used to indicate a layer 2 PDU, and the term SDU is used to indicated a layer 2 SDU. A receiver has a receiving window that is delimited by two state variables: VR(R) and VR(MR). VR(R) marks the beginning of the receiving window, and VR(MR) marks the end of the receiving window. The receiver expects to receive only PDUs that have SN values that land within the receiving window. Other PDUs are discarded. To better understand this, please refer to Fig.5. Fig.5 is a phase diagram 70 for a receiving window 73. In Fig.5, the receiving window 73 has a VR(R) = 3852 at position 71, and a VR(MR) = 206 at position 72. At position 74, the SN values roll over to zero. The receiving window 73 thus has a width of 450 PDUs. VR(MR) is always kept a fixed PDU SN value distance away from VR(R). That is, VR(MR) = VR(R) + the receiving window width (i.e., 450). As PDUs are received, the receiver advances VR(R), and thus advances the receiving window 73. VR(R) may not advance past any PDU that has not yet been properly received.

Please refer to Fig.6. Fig.6 is a phase diagram 80 for a transmitting window 83. In a manner analogous to the receiver,

a transmitter has a transmitting window 83 that is delimited by two state variables: VT(A) and VT(MS). VT(A) marks the beginning of the transmitting window 83, and VT(MS) marks the end of the transmitting window 83. For Fig.6, VT(A) = 3752 at position 81, and VT(MS) = 106 at position 82. Again, roll over to zero occurs at position 84. The transmitting window 83 is thus also 450 PDUs wide. The transmitter may only transmit PDUs that have SN values falling within the range of the transmitting window 83. The transmitter advances VT(A), and thus advances the transmitting window 83, upon reception of an acknowledgment status PDU from the receiver. The acknowledgment status PDU contains the most recent value of VR(R) from the receiver, and is sent periodically or upon receipt of a PDU with the polling bit 53 set. When an acknowledgment status PDU is received, the transmitter sets the state variable VT(A) equal to the VR(R) value contained in the acknowledgment status PDU. In this manner, the transmitting window 83 should ideally move forward in lock step with the receiving window 73.

As the receiving window 73 and the transmitting window 83 advance with each other, PDUs stream from the transmitter and are assembled into corresponding SDUs by the receiver. These SDUs are then passed in order to layer 3. As noted previously, under certain transmission modes the communications protocol requires that SDUs be delivered to layer 3 fully and in sequence. However, the protocol does allow SDUs to be discarded. This may occur, for example, due to a timeout, in which the data in the SDU is no longer relevant. A layer 2 transmitter can send control PDUs to a receiver indicating which SDUs are to be discarded. Upon reception of this control PDU, the receiver adjusts its receiving window 73 accordingly, and informs its

layer 3 of the SDUs that have been discarded. This control PDU for discarding SDUs is termed a Move Receiving Window (MRW) request PDU. Please refer to Fig.7. Fig.7 shows an MRW super-field 90 in an MRW request PDU 91. The MRW super-field 90 comprises a type field 92 of four bits that identifies the PDU 91 as an MRW request PDU, a length field 93 of four bits for indicating the number of subsequent SN_MRW entries 94, and an N_{Length} field 95 of four bits. Each SN_MRW entry 94 is used to indicate the end of a discarded SDU, and contains the SN value for the PDU that holds the end of the discarded SDU. The last entry 94, SN_MRW_{Length}, together with the N_{Length} entry 95 inform the receiver how the state variable VR(R) should be set. The N_{Length} entry 95 indicates how many LIs and corresponding data in the SN_MRW_{Length} PDU should be discarded. The length field 93 may hold a special case value of zero, which indicates that the MRW request PDU 91 holds a single SN_MRW entry 94 that extends beyond a transmitting window of the transmitter.

To better understand the above, please refer to Fig.8 and Fig.9. Fig.8 is a diagram of a string of SDUs 100. Fig.9 illustrates a sample MRW super-field 110 for discarding a portion of the SDUs 100 shown in Fig.8. In Fig.8, individual PDUs that carry the SDUs 100 are marked with dotted lines. SDU_11 ends in a PDU 101 having an SN value of 90. SDU_12 ends in a PDU 102 having an SN value of 95. SDU_13 and SDU_14 both end in a PDU 103 having an SN value of 96. Finally, SDU_15 begins in a PDU 104 with an SN value of 97. To discard SDU_11, SDU_12 and SDU_13, a transmitter builds the MRW super-field 110 and sends the MRW super-field 110 to the receiver as an MRW request PDU 111. The type field 112 is set to an MRW type indicator. The length field 113 holds a value of three,

indicating that three SN_MRW entries follow. SN_MRW_1 entry 114 is set to 90, indicating the end position of SDU_11 that is to be discarded, corresponding to PDU 101. The second entry SN_MRW_2 is set to 95, indicating that SDU_12, which is to be discarded, ends in PDU 102. Finally, the last entry SN_MRW_3 116 together with N_3 117 equal to 1 indicates that the first LI in PDU 103, and the data the LI references, are to be discarded. This corresponds, then, to throwing out SDU_13. SDU_14, on the other hand, is kept.

Please refer to Fig.10 with reference to Fig.8. Fig.10 illustrates another MRW super-field 120. A special case exists when a transmitter wishes to discard a single SDU that extends outside the transmitter window. For example, arrow 106 in Fig.8 represents the end of the transmitting window, which is at an SN value of 98. That is, VT(MS) = 98. SDU_15, however, ends in a PDU 105 that has an SN value of 99, which is beyond VT(MS). To discard SDU_15, the transmitter creates the MRW super-field 120 with a length field 123 having a value of zero. A zero value in the length field 123 indicates to the receiver that a single SDU is being discarded that extends beyond the range of the transmitting window. SDU_15 ends in PDU 105 having an SN value of 99, so the SN_MRW_1 field 124 is set to 99. The last field 125, the so-called N_{Length} field, is set to one, indicating that the first LI in PDU 105, and the data so referenced, is to be discarded.

Please refer to Fig.11. Fig.11 is an SN phase diagram 130 for SDUs ending at 132a and 132b to be discarded. Both a transmitter and a receiver (not shown) share an identical window 134 that is 600 PDUs wide, having a starting point 134a with an SN value of 3696, and an ending point 134b with an SN value

of 200. That is, for the receiver, VR(R) = 3696 at point 134a, and VR(MR) = 200 at point 134b, forming the receiving window 134. Similarly, for the transmitter, VT(A) = 3696, and VT(MS) = 200, forming the transmission window 134. Point 131 indicates an SN value of zero. The transmitter wishes to discard two SDUs: the SDU ending at position 132a having an SN value of 3796, and the SDU ending at position 132b, sequentially after the position 132a, having an ending SN value of 450. Please refer to Fig.12 with reference to Fig.11. Fig.12 illustrates an MRW request PDU 141 holding an MRW super-field 140 to effect the SDU discards of Fig.11. Type field 142 indicates that the PDU 141 is an MRW request PDU. Length field 143 has a value of three, indicating that three SN_MRW entries follow. SN_MRW_1 144 marks the ending PDU at point 132a of the first discarded SDU. SN_MRW_2 145 marks the ending PDU at point 132b of the second discarded SDU. The SDU ending at position 132b totally fills its final PDU, and hence the final SN_MRW entry 146 in the MRW super-field 140 holds a value of 451, and the N field 147 holds a value of zero. The final fields 146 and 147 indicate to the receiver that all data is to be kept in the PDU having an SN value of 451, whereas all the data is to be discarded in the PDU having an SN value of 450.

When processing the MRW super-field 140 in the MRW request PDU 141, the receiver must determine the sequence order of the SDU 132b, as given by SN_MRW_2 field 145. As the sequencing is circular, the SDU 132b may be after the end of the receiving window 134, i.e., be sequentially after VR(MR) at 134b. This is, in fact, the intention of the transmitter. However, it is also possible that the SDU 132b was meant to indicate an SDU that was sequentially before the start of the receiving window 134, i.e., sequentially before VR(R) at 134a. To properly

resolve this ambiguity, the protocol states that if any SDUs land within the receiving window 134, then other SDUs outside of the receiving window 134 are to be considered after VR(MR), i.e., after the end of the receiving window 134 at the point 134b. On the other hand, if none of the SDUs land within the receiving window 134, then all of the SDUs are to be considered before VR(R), i.e., before the start of the receiving window 134 at point 134a. As the SDU 132a lies within the receiving window 134, using this protocol, the receiver properly recognizes that the SDU ending at 132b is sequentially after VR(MR) at 134b.

Please refer to Fig.13. Fig.13 is an alternative SN phase diagram 150 for the SDUs indicated in Fig.11 and Fig.12. Item numbers in Fig.11 and Fig.13 are kept identical for those items that are identical in nature. In Fig.11, both the receiving window and the transmitting window lay upon the same window 134. This is not the general case, however. In general, the receiving window will advance beyond the transmitting window since the receiver reports an acknowledgement status on a periodic base or after it receives a poll from the transmitter, which does not trigger a poll with every PDU. Additionally, the transmitter may occasionally fail to receive an acknowledgment status PDU from the receiver, and thus will not update its transmitting window to reflect the new state of the receiving window. In Fig.13, arrow 136 indicates the extents of a transmitting window, with VT(A) at point 136a having an SN value of 3696, and VT(MS) at point 136b with an SN value of 200. This is identical, then, to the window 134 of Fig.11. Arrow 138 represents the extents of the receiving window, which has advanced 200 PDU units past the transmitting window 136. The receiving window 138 has a VR(R) value of 3896

at point 138a, and a VR(MR) value of 400 at point 138b. In this case, when the receiver receives the MRW request PDU 141 of Fig.12, the indicated SDUs ending at 132a and 132b respectively will be treated differently. As neither 132a nor 132b lie within the receiving window 138, the receiver will treat both respective SDUs as being prior to VR(R) at point 138a, and hence ignore the SDU discard request for the SDU ending at 132b. That is, the receiver will believe that the SDUs ending at 132a and 132b have already been received, and hence will not discard the SDU ending at 132b as requested by the transmitter. The sequential ordering of the SDU ending at 132b is misconstrued by the receiver protocol rules.

SUMMARY OF THE INVENTION

It is therefore a primary objective of this invention to provide a method for determining the sequential ordering of layer 2 protocol data units (PDUs) in a move receiving window (MRW) request sent to a receiver in a wireless communications system to discard at least one layer 2 service data unit (SDU).

Briefly summarized, the preferred embodiment of the present invention discloses building a layer 2 MRW super-field that has a PDU sequence number for each layer 2 SDU to be discarded. Within the MRW super-field there is an initial sequence number that is arranged within the MRW super-field according to a packing algorithm. The MRW super-field is transmitted to the receiver, and the receiver extracts the initial sequence number. The receiver then assumes that all other PDU sequence numbers within the MRW super-field are sequentially after the initial sequence number to effect the discarding of layer 2 SDUs.

It is an advantage of the present invention that by establishing a reference sequence number, the receiver is able to properly determine the correct ordering of layer 2 PDUs when discarding layer 2 SDUs, and thus the receiver will not mistakenly discard or accept incorrect layer 2 SDUs.

These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment, which is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a block diagram of a three-layer communications protocol.

Fig.2 is a diagram of a transmission/reception process from a layer 2 perspective.

Fig.3 is a block diagram of a layer 2 protocol data unit (PDU).

Fig.4 is a phase diagram of a sequence number transmission cycle.

Fig.5 is a phase diagram for a receiving window.

Fig.6 is a phase diagram for a transmitting window.

Fig.7 shows a move receiving window (MRW) super-field in an MRW request PDU.

Fig.8 is a diagram of a string of layer 3 service data units (SDUs).

Fig.9 illustrates a sample MRW super-field for discarding a portion of the SDUs shown in Fig.8.

Fig.10 illustrates another MRW super-field.

Fig.11 is a sequence number (SN) phase diagram for SDUs

to be discarded.

Fig.12 illustrates an MRW request PDU holding an MRW super-field to effect the SDU discards of Fig.11.

Fig.13 is an alternative SN phase diagram for the SDUs indicated in Fig.11 and Fig.12.

Fig.14 is a block diagram of a communications system according to the method of the present invention.

Fig.15 is a block diagram of SDUs within a string of PDUs.

Fig.16 is a block diagram of an MRW super-field according to the present invention.

Fig.17 is a block diagram of an MRW request PDU sent by a transmitter of the present invention to a receiver of the present invention.

Fig.18 is an SN phase diagram for a transmitter and receiver shown in Fig.14.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In the following description, a communications protocol as disclosed in the 3GPP™ specification TS 25.322, V3.4.0, is used by way of example. However, it should be clear to one in the art that any wireless communications protocol that suffers from ambiguity of layer 2 sequence numbers when discarding layer 3 data can benefit from the method and system of the present invention.

It is the method of the present invention to build a Move Receiving Window (MRW) super-field with layer 2 protocol data unit (PDU) sequence numbers that are packed according to the sequentiality of the sequence numbers. Specifically, an initial sequence number is packed within the MRW super-field according to a packing algorithm. All other sequence numbers in the MRW

super-field are sequentially after this initial sequence number. The MRW super-field is sent to the receiver, and the receiver extracts the initial sequence number from the MRW super-field using an extraction algorithm. The receiver then assumes that all other sequence number within the MRW super-field are sequentially after the initial sequence number.

Please refer to Fig.14. Fig.14 is a block diagram of a communications system 200 that utilizes the method of the present invention. The communications system 200 comprises a transmitter 210 and a receiver 220. The transmitter 210 uses a three-layer communications protocol, comprising a layer 1 interface 201, a layer 2 interface 202 and a layer 3 interface 203. The receiver 220 uses a similar protocol, and has a layer 1 interface 221, a layer 2 interface 222 and a layer 3 interface 223. Layer 2 service data units 206 and 226 (SDUs) are exchanged between layers 2 and 3, and layer 2 protocol data units (PDUs) 207 and 227 are exchanged between layers 1 and 2. The form and functionality of the transmitter 210, the receiver 220, layer 2 SDUs 206 and 226, and layer 2 PDUs 207 and 227 are nearly identical to that of the disclosed prior art. However, the layer 2 interfaces 202 and 222 of the present invention communications system 200 have additional functionality to determine sequence number (SN) ordering of layer 2 PDUs when processing a move receiving window (MRW) request. The layer 2 interface 202 of the transmitter 210 comprises a packing algorithm 208 that is used when building an (MRW) super-field in an MRW request PDU. The packing algorithm 208 orders the layer 2 PDU SN values within the MRW super-field according to the sequentiality of the SN values. Similarly, the layer 2 interface 222 within the receiver 220 comprises an extracting algorithm 228 that enables the receiver 220 to determine the

sequentiality of SN values within an MRW super-field as packed by the transmitter 210. The extracting algorithm 228 can be loosely thought of as the inverse function of the packing algorithm 208. In the present invention, the packing algorithm 208 simply places the SN values into the MRW super-field in increasing sequential order. The extracting algorithm 228 thus assumes that the MRW super-field SN values are in sequential order, from sequentially first to sequentially last layer 2 PDU SN values. Other packing 208 and extracting 228 algorithms are certainly possible, however. The key point is that the packing algorithm 208 and extracting algorithm 228 together enable the receiver 220 to determine layer 2 PDU SN value sequentiality in an MRW super-field. In particular, the packing algorithm 208 enables the receiver 220 to extract a reference point SN value from an MRW super-field. In the preferred embodiment, this reference point SN value is sequentially before all other SN values in the MRW super-field. Other reference points are also possible. Regardless of what reference point SN value is used, though, an initial value that is sequentially before all other SN values will subsequently be found.

In the following discussion, the term PDU is used to indicate layer 2 PDUs. Similarly, the term SDU is used to indicate layer 2 SDUs. To better understand the above-mentioned method of the present invention, please refer to Fig.15 and Fig.16, with reference to Fig.14. Fig.15 is a block diagram of SDUs 230 within a string of PDUs. Fig.16 is a block diagram of an MRW super-field according to the present invention. In Fig.15, a plurality of SDUs 230, labeled SDU_21 to SDU_25, are sent by the transmitter 210 to the receiver 220. The individual PDUs that actually carry the SDUs 230 are indicated by dotted

lines. We may imagine, however, that due to a timeout, the transmitter 210 wishes the receiver 220 to discard SDU_21, SDU_22, SDU_23 and SDU_24. The transmitter 210 thus uses the packing algorithm 208 to build an MRW super-field 240 within an MRW request PDU 241, and sends the MRW request PDU 241 to the receiver 220. SDU_21 ends in a PDU 231 having an SN value of 4092. SDU_22 ends in a PDU 232 with an SN value of 1, due to subsequent roll-over of the 12 bits in the SN field of the PDU, as disclosed in the prior art. SDU_23 and SDU_24 both end in a PDU 233 having an SN value of 2. Finally, SDU_25 begins in PDU 234, which has an SN value of 3. The packing algorithm 208 builds the MRW super-field 240 so that the PDU SN values are in increasing sequential order. Specifically, the SN value of the initial PDU 231, after which all the other PDUs 232, 233 and 234 follow, is placed within the first SN_MRW field 244, immediately after the length indicator (LI) field 243.

After receiving the MRW request PDU 241, the extracting algorithm 228 within the receiver 220 uses the following assumptions to determine the proper sequential ordering of the PDU SN values within the SN_MRW fields 249 of the MRW super-field 240:

1) If the length field 243 is the special case value of zero, then the transmitter 210 is requesting a discard of a single SDU that extends up to or beyond the transmitter state variable VT(MS) 205, which marks the first SN outside of the transmitting window. The MRW super-field 240 thus has only one SN_MRW field, and this single SN_MRW entry is assumed to be sequentially after state variable VR(R) 224, which is the starting point of the receiving window of the receiver 220.

2) If the length field 243 is non-zero, then the first SN_MRW entry 244 after the length field 243 is an initial SN value that is assumed to be sequentially on or before all subsequent SN_MRW field values 249. Additionally, this initial SN value 244 is assumed to be sequentially before state variable VR(MR) 225, which marks the first SN outside of the receiving window of the receiver 220.

In Fig.16, then, the SN value of 4092 is assumed by the receiver 220 to be sequentially before the SN values of 1, 2 and 3. Additionally, the SN value 4092 is assumed to be sequentially before VR(MR) 225. The other SN values within the SN_MRW fields 249 are then ordered accordingly.

As a further example of the above, please refer to Figs.17 and 18 with reference to Fig.14. Fig.17 is a block diagram of an MRW request PDU 251 sent by the transmitter 210 to the receiver 220. Fig.18 is an SN phase diagram 260 for the transmitter 210 and receiver 220. The MRW request PDU 251 has an MRW super-field 250 that requests discarding of an initial SDU 254 that ends at point 262a with an SN value of 3796, and discarding of a subsequent SDU 255 that ends at point 262b with an SN value of 450. Both the transmitting window 266 and the receiving window 268 are 600 PDU units wide. State variable VT(A) 204 for the transmitter 210 indicates point 266a with an SN value of 3696. State variable VT(MS) 205 of the transmitter 210 indicates point 266b, with an SN value of 200. The receiver 220 has state variable VR(R) 224 indicating point 268a, with an SN value of 3896, and VR(MR) 225 indicating point 268b with an SN value of 400. Upon reception of the MRW super-field 250, the extracting algorithm 228 determines that the first SN_MRW field 254 holds the initial SN value, which is 3796. The receiver

thus assumes that point 262a lies before the receiving window 268 end point state variable VR(MR) 225 at point 268b. Additionally, the extracting algorithm assumes that the second SN_MRW entry 255 is sequentially after the initial SN_MRW entry 254. Thus, the receiver 220 properly assumes that the end point 262b of SDU 255 lies sequentially after VR(MR) 225. Hence, the receiver will properly discard SDU 255.

In contrast to the prior art, the present invention provides a method and corresponding system that correctly determines the order of sequence numbers when processing a move receiving window command. The sequence numbers in the move receiving window super-field are packed according to a packing algorithm so that an initial sequence number can be extracted by the receiver using an extraction algorithm. The receiver assumes that all other sequence numbers in the move receiving window super-field are after the initial sequence number.

Finally, it should be noted that the present invention is applicable to various wireless environments, such as mobile telephony, personal data assistants (PDAs), handheld radio-transmitters, etc. Also, it should be clear to one skilled in the art that various physical layers are possible for the implementation of layer 1.

Those skilled in the art will readily observe that numerous modifications and alterations of the device may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

CLAIMS

What is claimed is:

1. A method for determining sequential ordering of layer 2 protocol data units (PDUs) during a layer 2 move receiving window (MRW) request sent to a receiver in a wireless communications system by a transmitter to discard at least a layer 2 service data unit (SDU), the method comprising:

building a layer 2 MRW super-field comprising a layer 2 PDU sequence number for each layer 2 SDU to be discarded, an initial sequence number arranged within the MRW super-field according to a packing algorithm;

transmitting the MRW super-field to the receiver;

extracting the initial sequence number from the MRW super-field according to an extracting algorithm; and

assuming layer 2 PDU sequence numbers within MRW super-field are all sequentially on or after the initial sequence number when determining the sequential ordering of layer 2 PDUs for discarding each layer 2 SDU.

2. A method according to claim 1 wherein a fixed bit length is used for the layer 2 PDU sequence numbers in the MRW super-field, and roll-over is capable of causing a first sequence number in the MRW super-field to have a lower value than a second sequence number in the MRW super-field, the first sequence number being sequentially after the second sequence number.

3. A method according to claim 1 wherein the MRW super-field further comprises a length field, the length field indicating the number of layer 2 PDU sequence numbers in the MRW super-field.

4. A method according to claim 3 wherein a special case value is used for the length field to indicate that the MRW super-field holds a single layer 2 PDU sequence number for a single layer 2 SDU that is to be discarded and that extends beyond a transmitting window of the transmitter, and the layer 2 PDU sequence number is assumed to be sequentially on or after a starting point sequence number of a receiving window of the receiver.

5. A method according to claim 4 wherein the MRW super-field comprises either a plurality of layer 2 PDU sequence numbers, or a single layer 2 PDU sequence number without using the special case value for the length field, and the initial sequence number is assumed to be sequentially before an end point sequence number of the receiving window of the receiver.

6. A wireless communications system that uses a layer 2 protocol data unit (PDU) having a move receiving window (MRW) request to discard at least a layer 2 service data unit (SDU), the wireless communications system comprising:

a transmitter capable of transmitting a layer 2 MRW super-field comprising a layer 2 PDU sequence number for each layer 2 SDU to be discarded, an initial sequence number arranged within the MRW super-field according to a packing algorithm; and

a receiver capable of receiving the transmitted MRW super-field and extracting the initial sequence number from the MRW super-field according to an extracting algorithm;

wherein the receiver assumes that the layer 2 PDU sequence numbers within MRW super-field are all sequentially on or after

the initial sequence number when determining the sequential ordering of layer 2 PDUs for discarding each layer 2 SDU.

7. A wireless communications system according to claim 6 wherein a fixed bit length is used for the layer 2 PDU sequence numbers in the MRW super-field, and roll-over is capable of causing a first sequence number in the MRW super-field to have a lower value than a second sequence number in the MRW super-field, the first sequence number being sequentially after the second sequence number.

8. A wireless communications system according to claim 6 wherein the MRW super-field further comprises a length field, the length field indicating the number of layer 2 PDU sequence numbers in the MRW super-field.

9. A wireless communications system according to claim 8 wherein a special case value is used for the length field to indicate that the MRW super-field holds a single layer 2 PDU sequence number for a single layer 2 SDU that is to be discarded and that extends beyond a transmitting window of the transmitter, and the layer 2 PDU sequence number is assumed to be sequentially on or after a starting point sequence number of a receiving window of the receiver.

10. A wireless communications system according to claim 9 wherein the MRW super-field comprises either a plurality of layer 2 PDU sequence numbers, or a single layer 2 PDU sequence number without using the special case value for the length field, and the initial sequence number is assumed to be sequentially before an end point sequence number of the receiving window of the receiver.

ABSTRACT OF THE DISCLOSURE

Within a move receiving window (MRW) super-field there is an initial sequence number that is arranged within the MRW super-field according to a set algorithm. The MRW super-field is transmitted to a receiver, and the receiver extracts the initial sequence number. The receiver then assumes that all other layer 2 PDU sequence numbers within the MRW super-field are sequentially after the initial sequence number to effect discarding of layer 2 SDUs. The initial sequence number is assumed to be either sequentially on or after a starting point sequence number, or sequentially before an end point sequence number of a receiving window of the receiver, depending on whether a special case value exists for the length field of the MRW super-field. The special case value indicates that a single SDU that extends beyond a transmitting window of the transmitter is to be discarded.

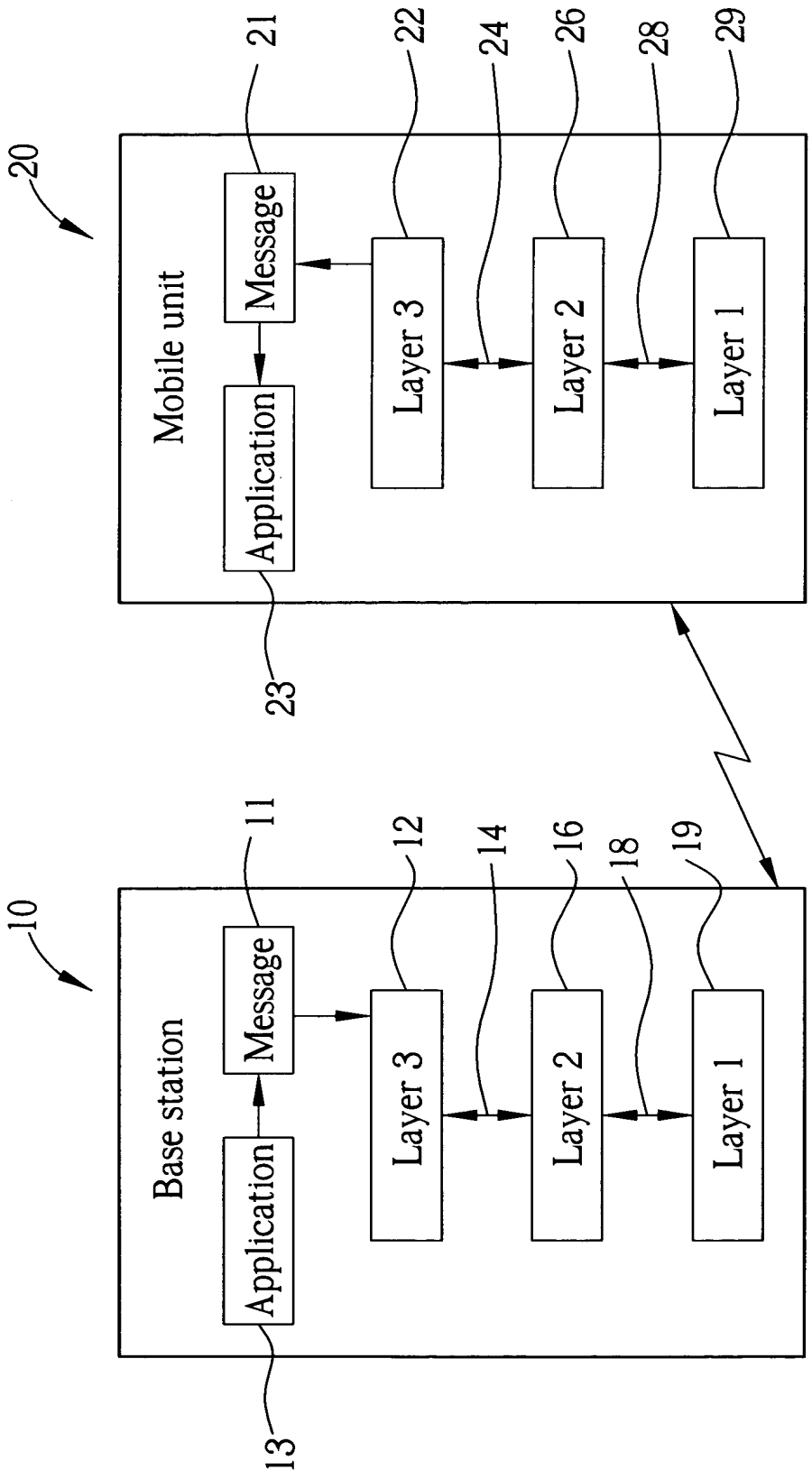

Fig. 1 Prior art

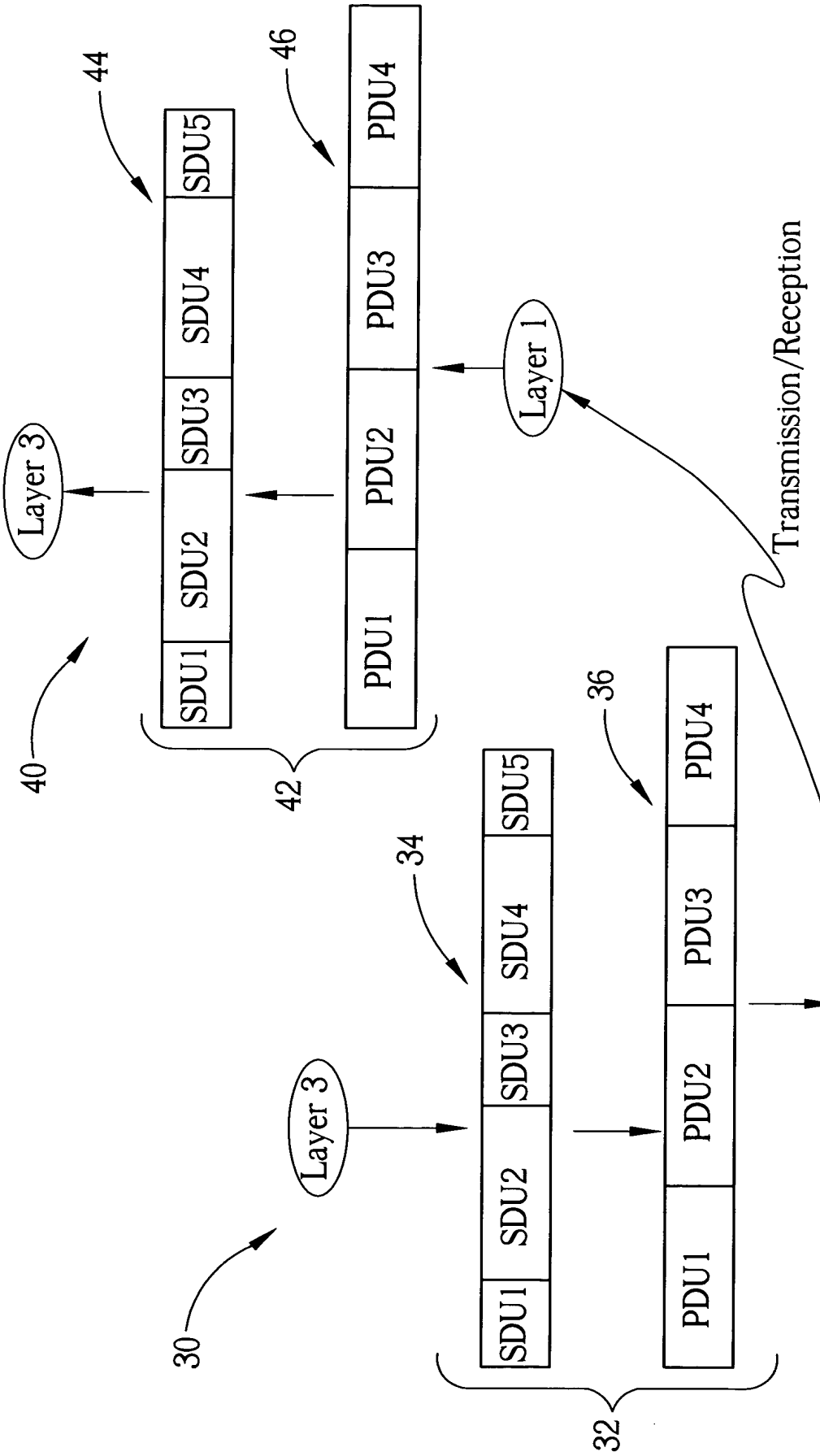

Fig. 2 Prior art

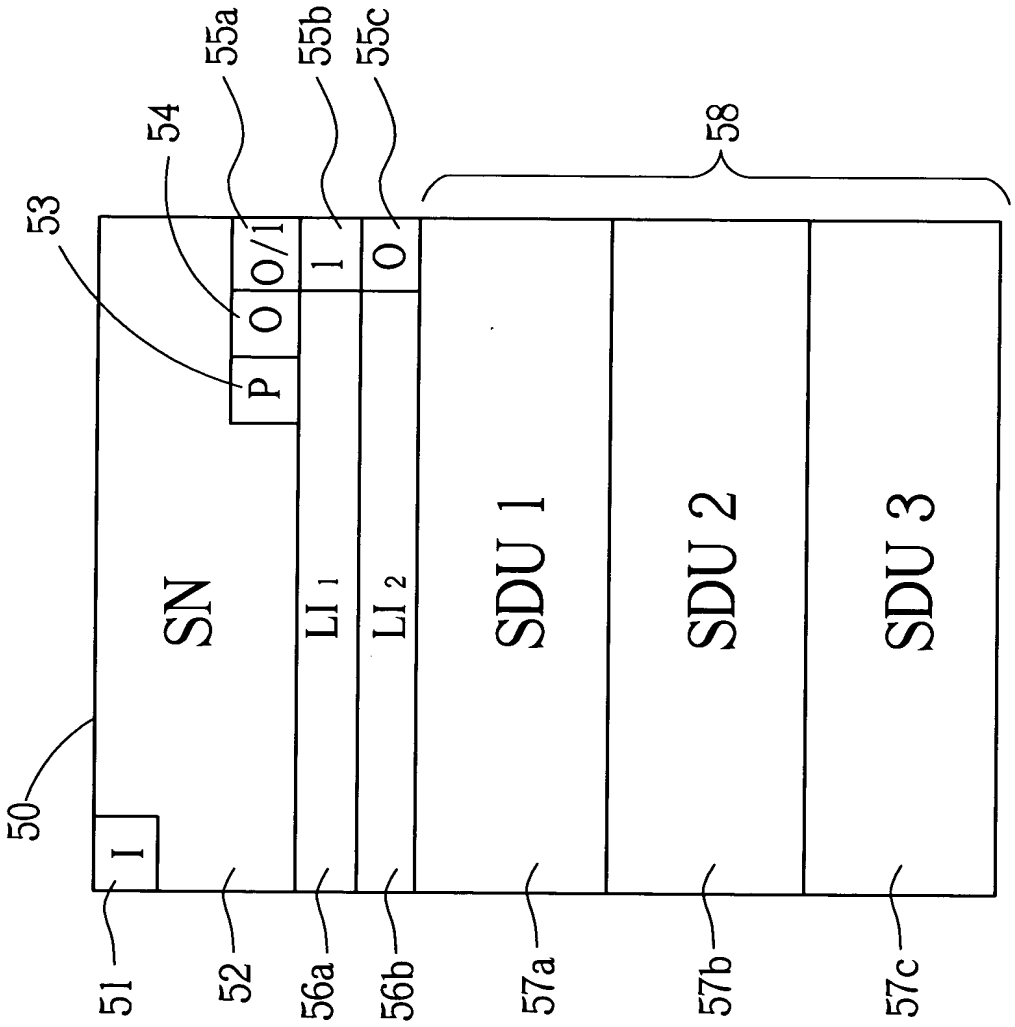

Fig. 3 Prior art

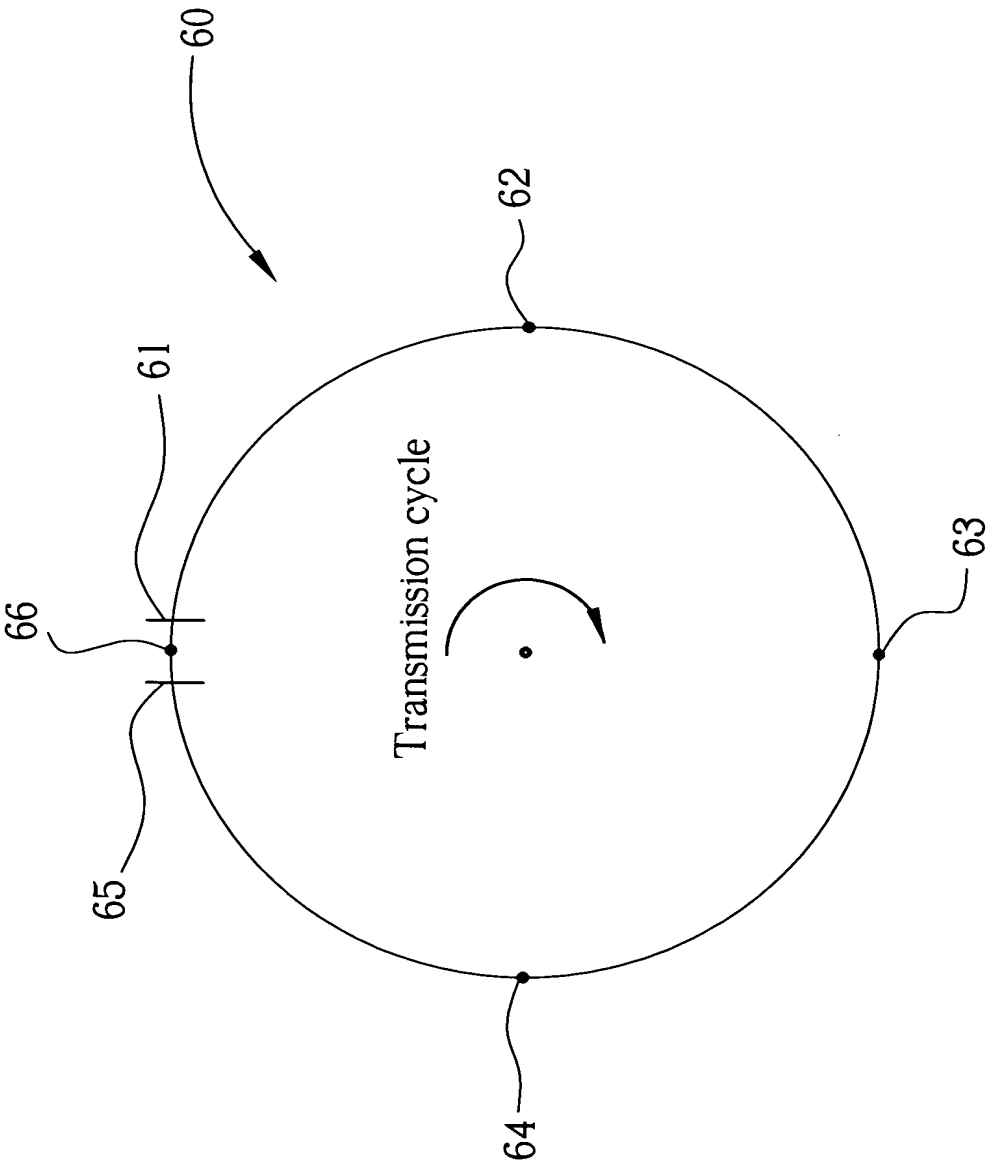

Fig. 4 Prior art

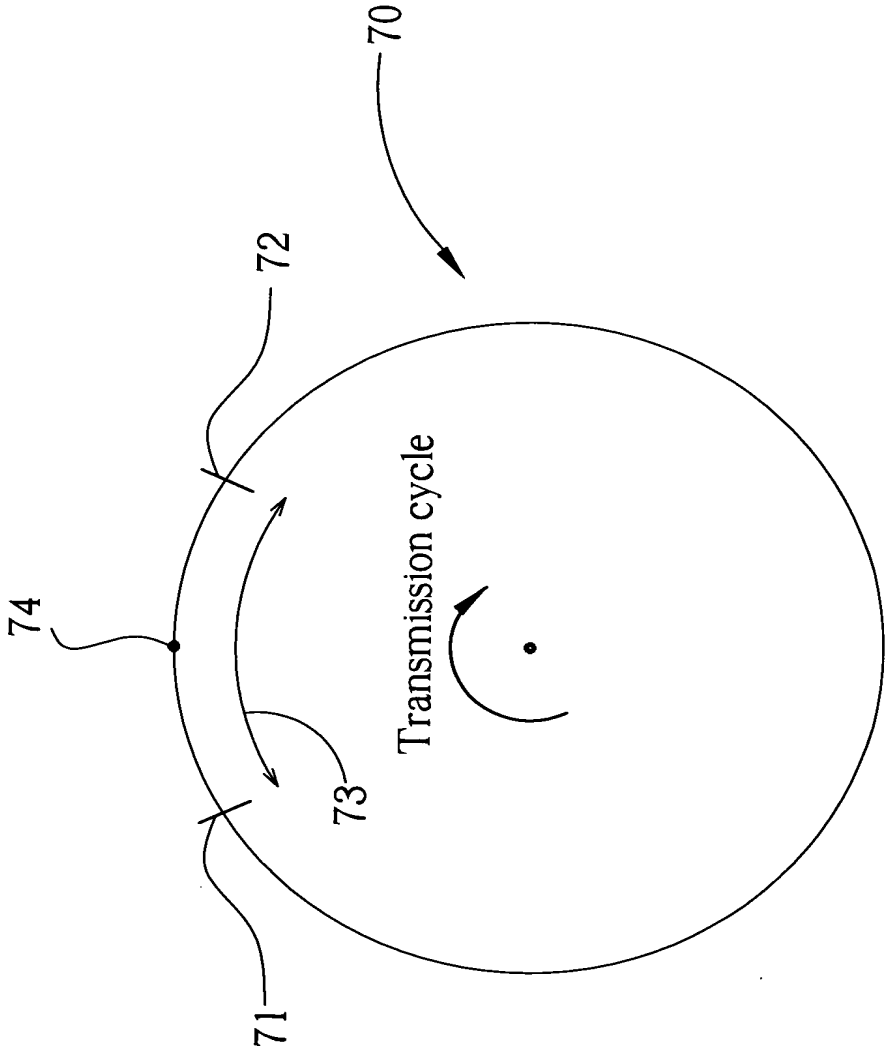

Fig. 5 Prior art

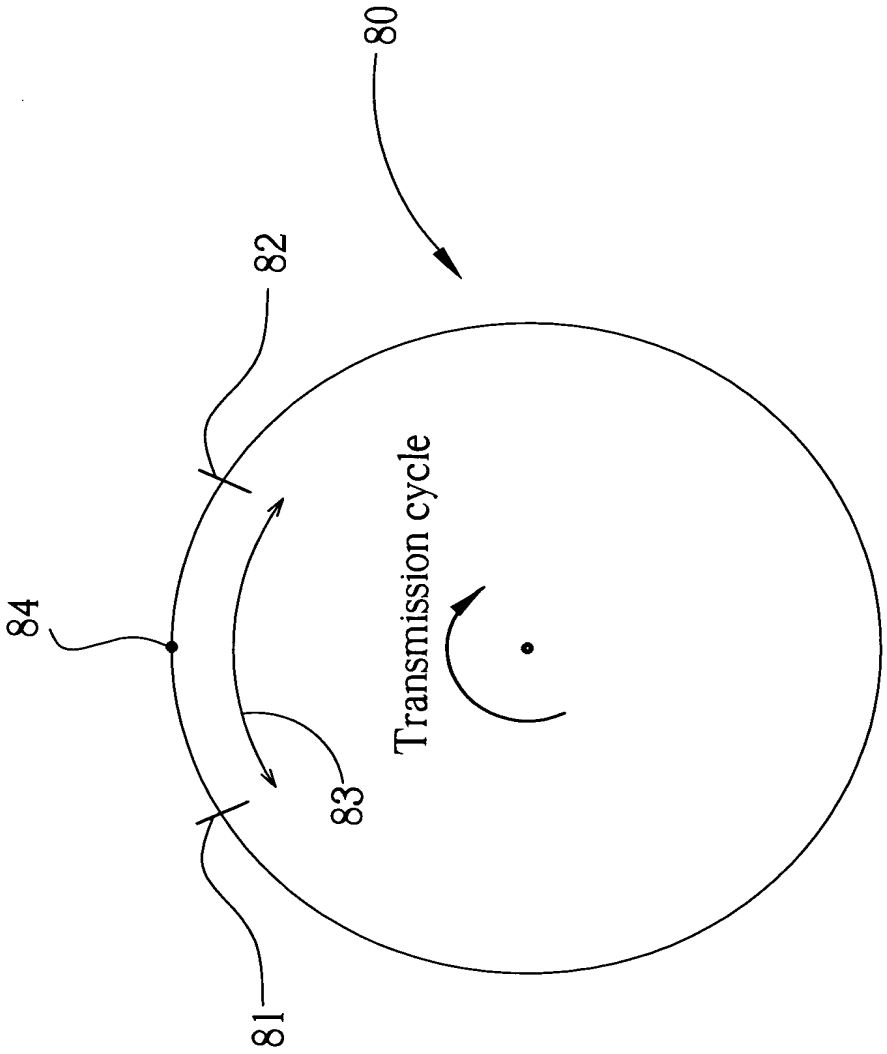

Fig. 6 Prior art

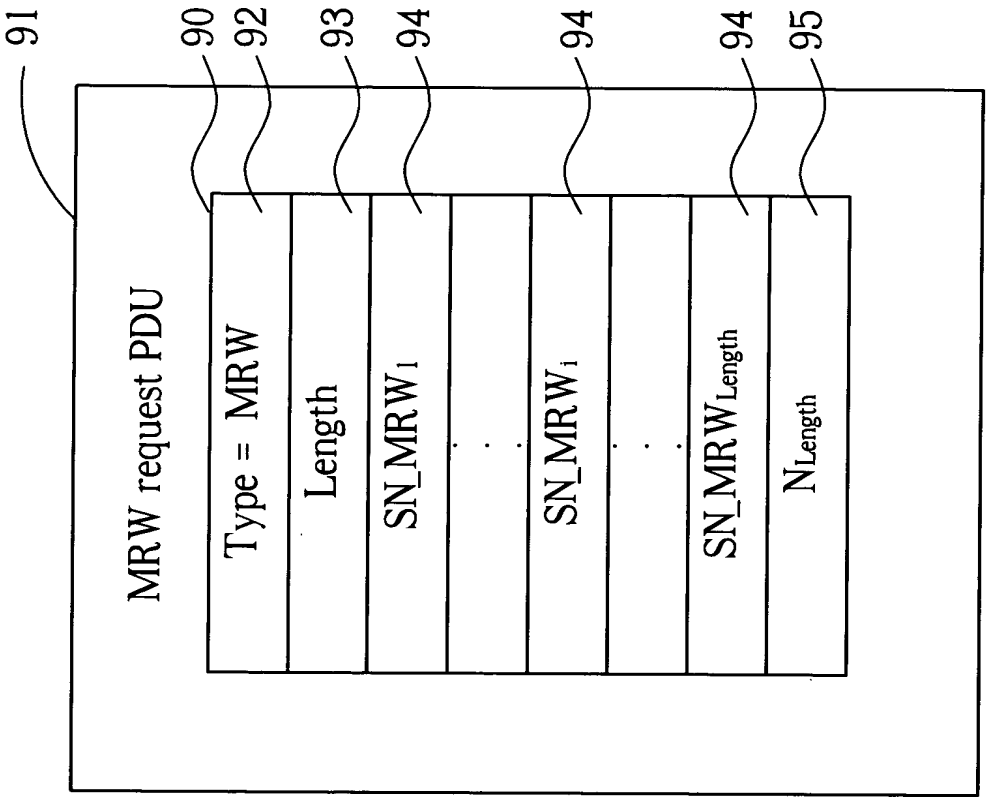

Fig. 7 Prior art

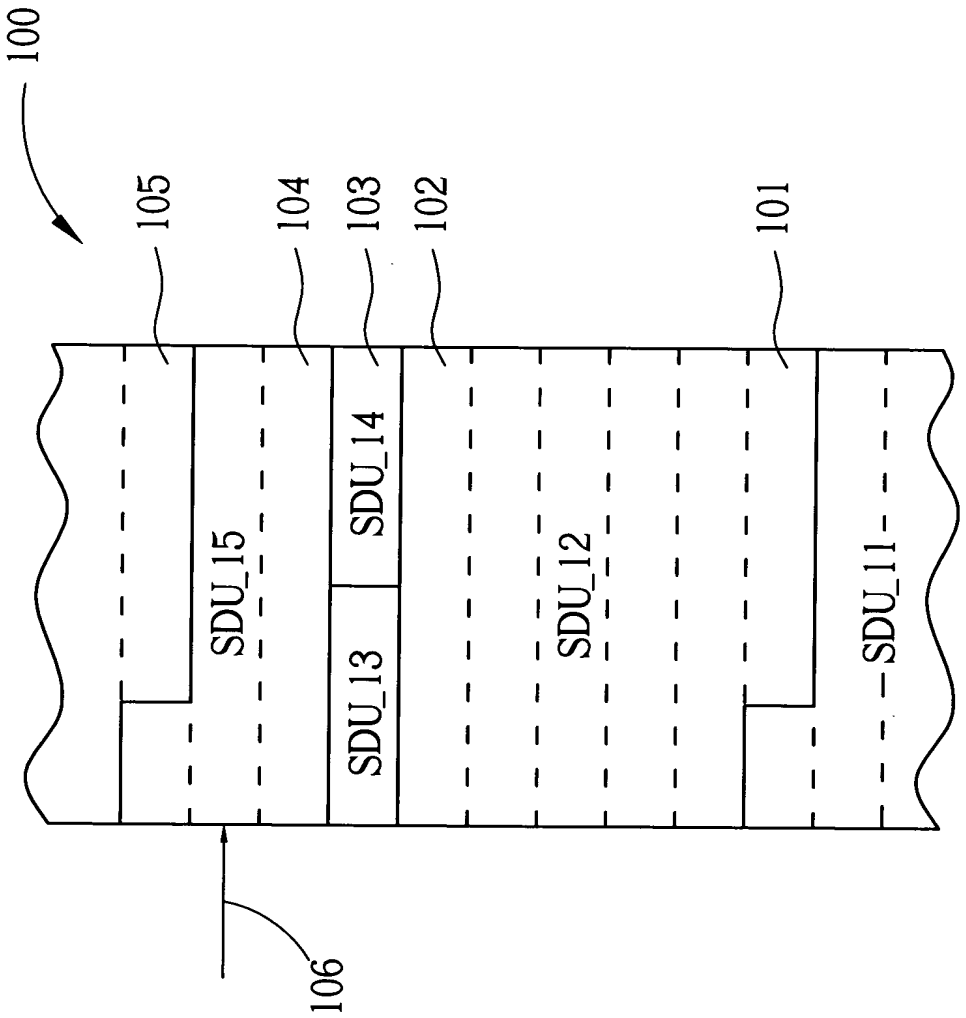

Fig. 8 Prior art

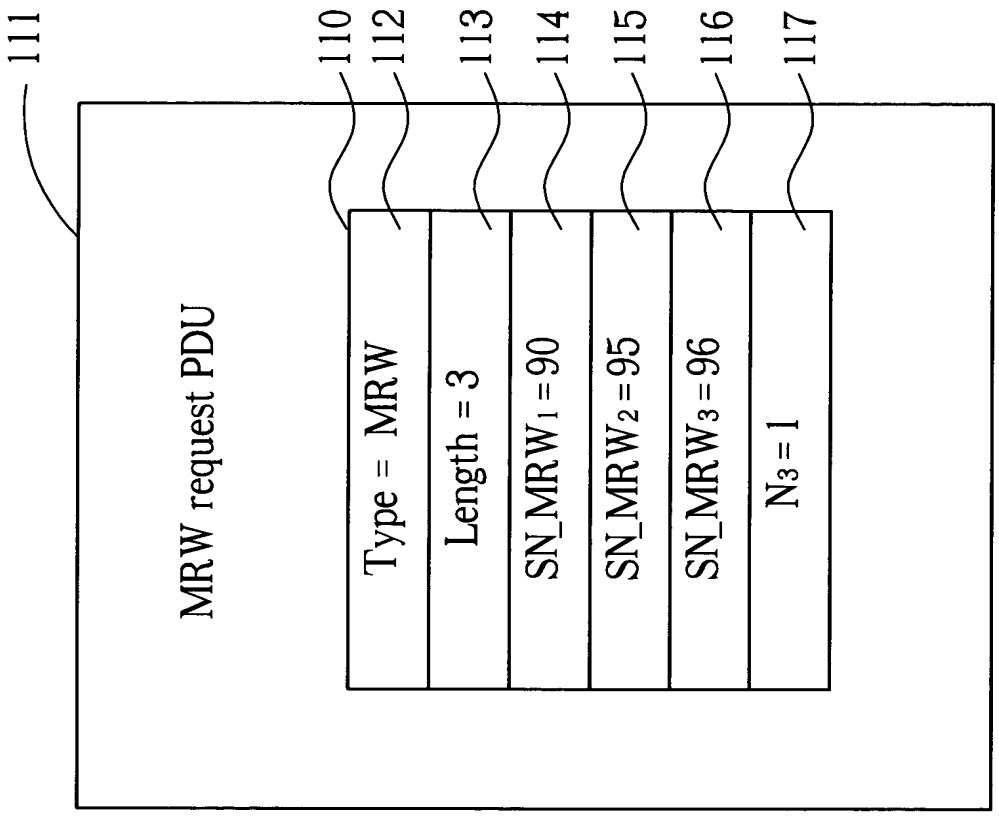

Fig. 9 Prior art

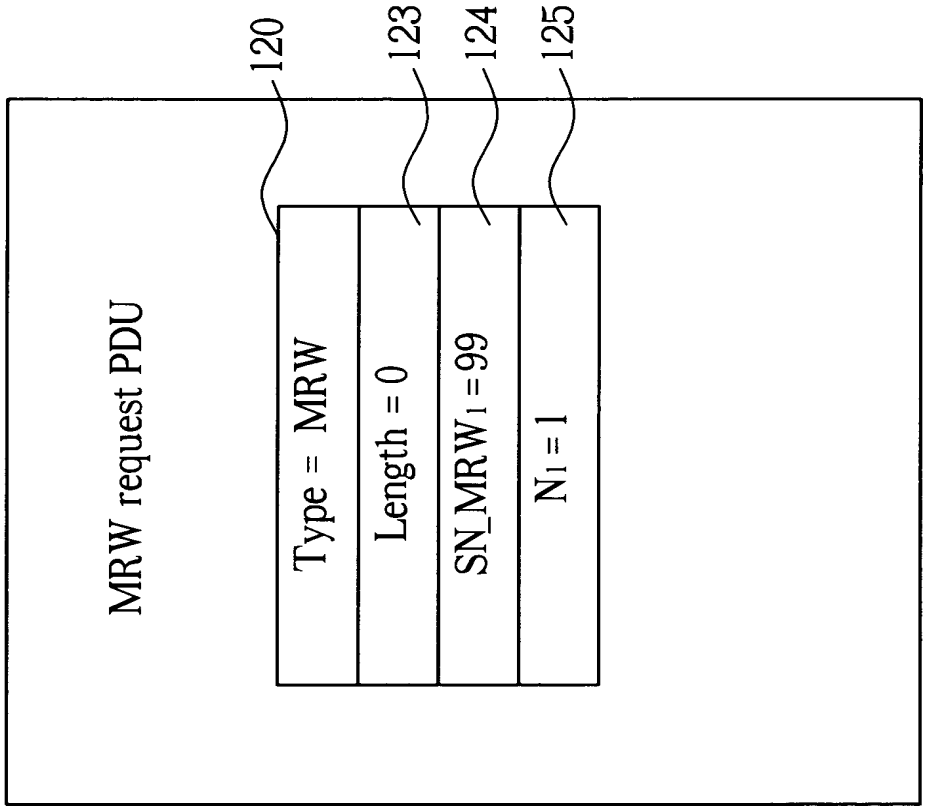

Fig. 10 Prior art

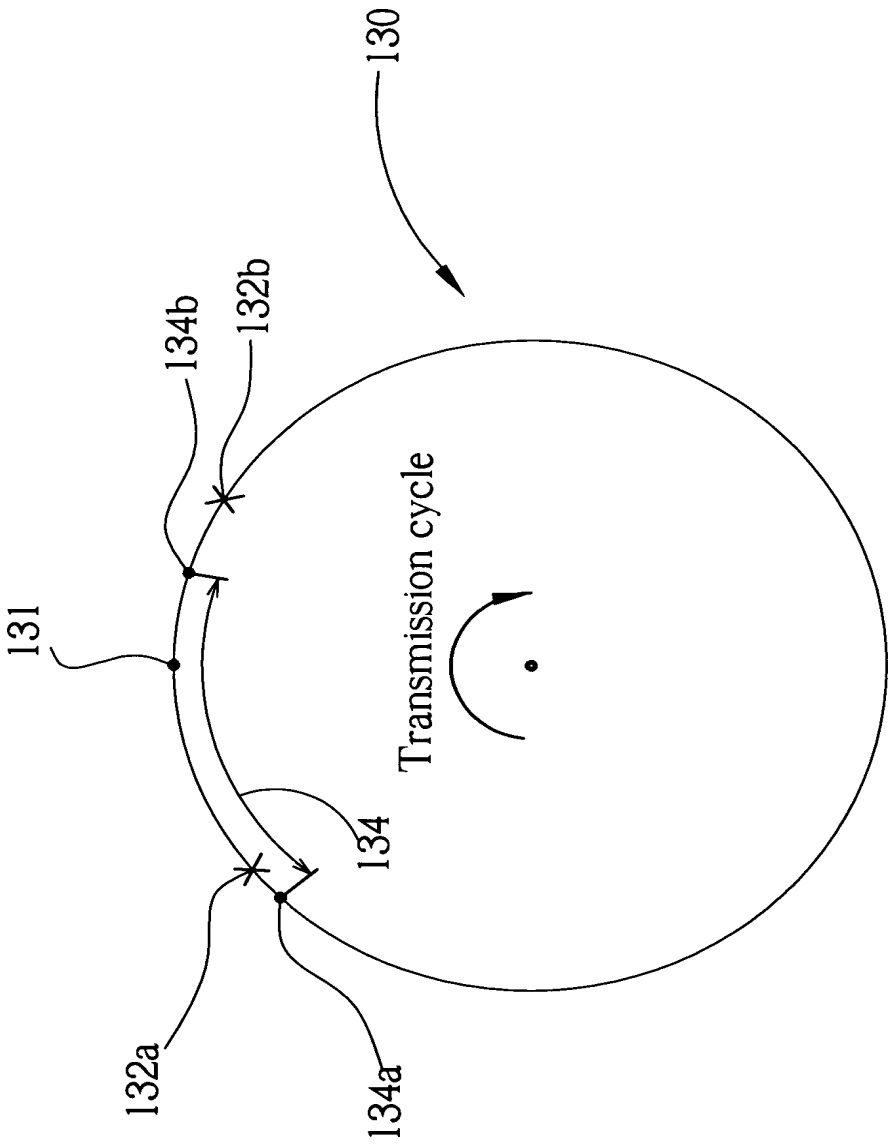

Fig. 11 Prior art

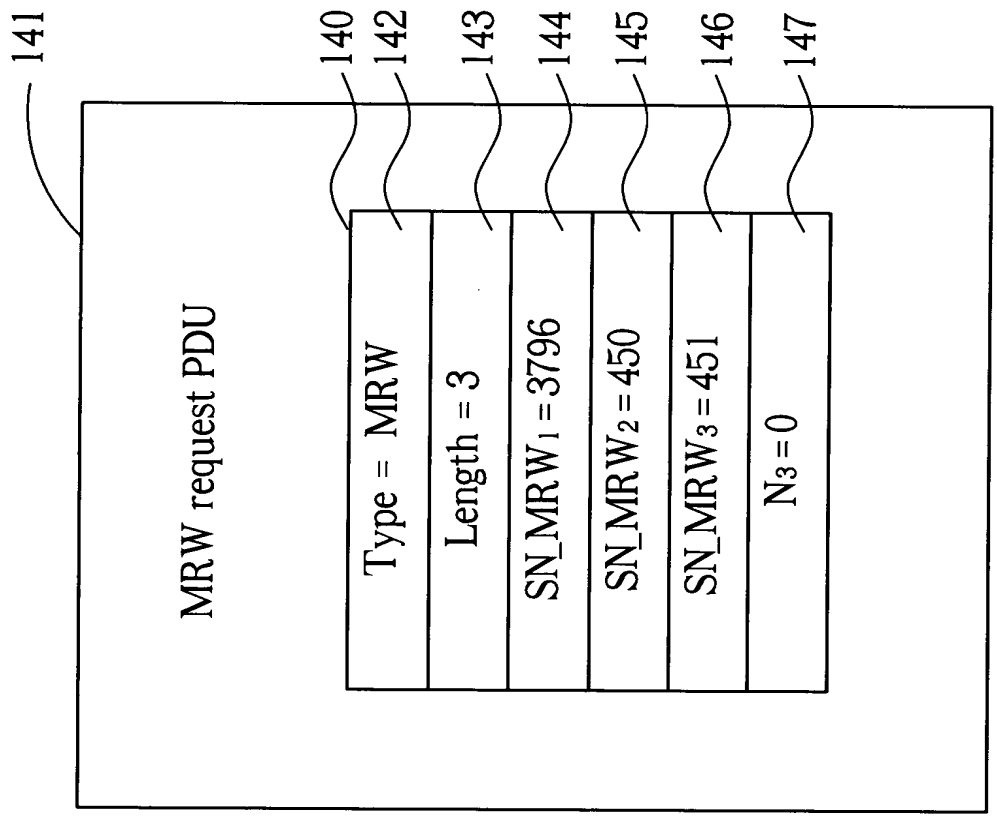

Fig. 12 Prior art

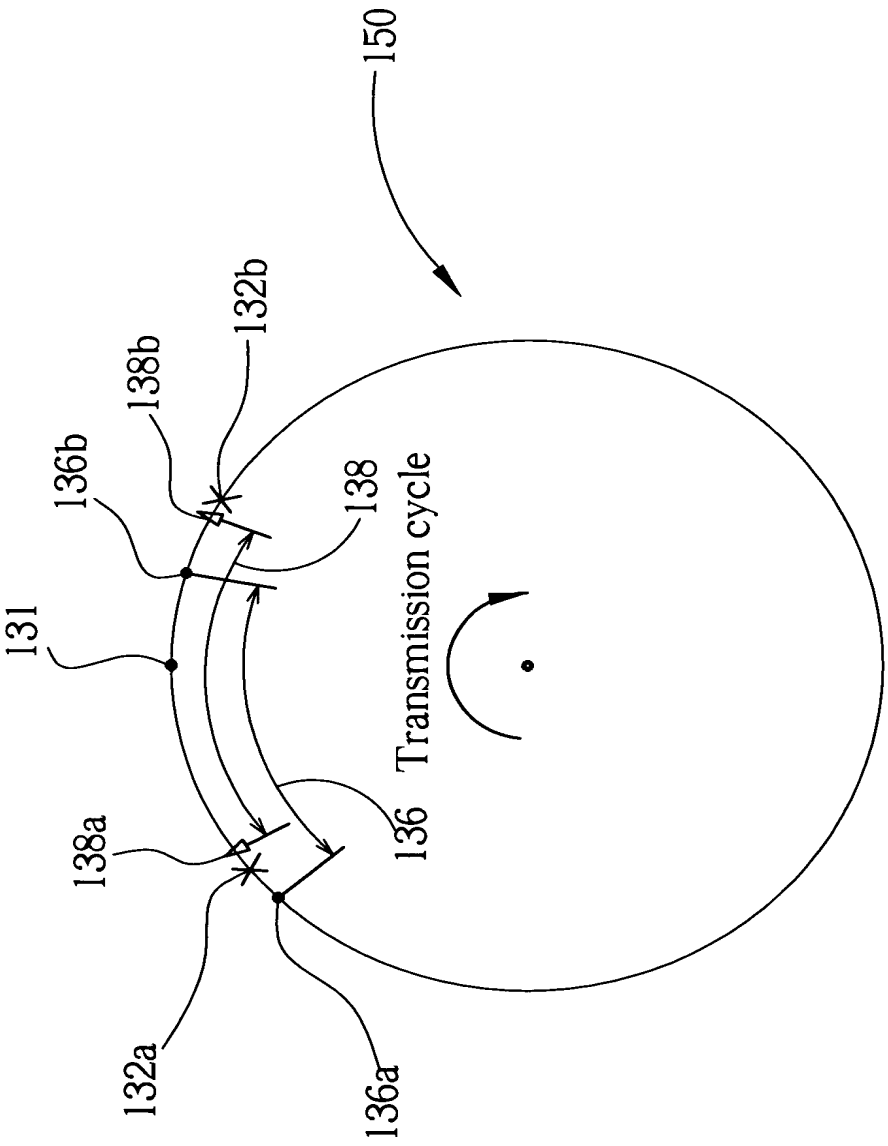

Fig. 13 Prior art

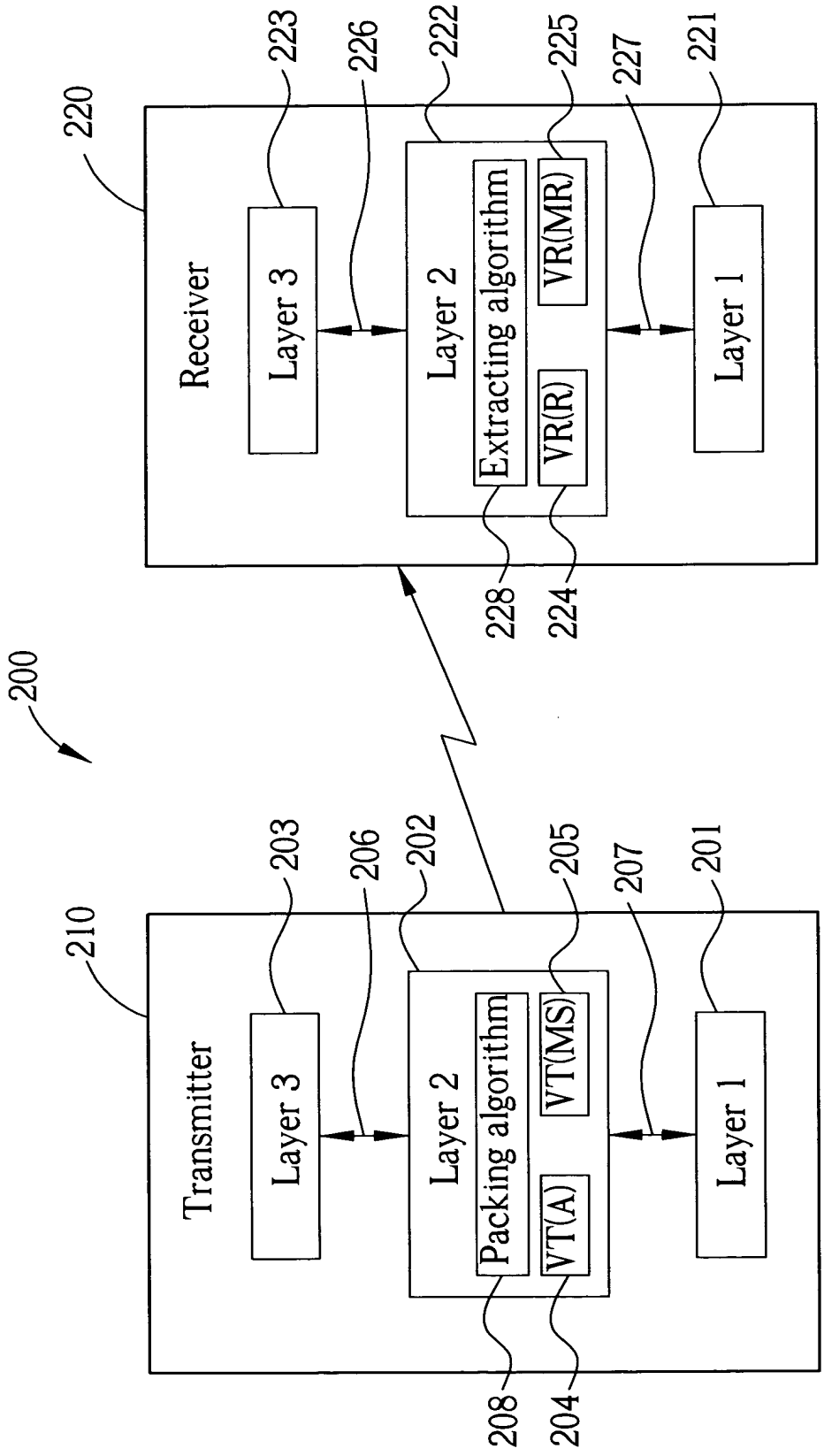
200
210
Transmitter
Layer 3
Layer 2
Packing algorithm
VT(A)
VT(MS)
Layer 1
203
206
202
205
207
201
208
204
220
Receiver
Layer 3
Layer 2
Extracting algorithm
VR(R)
VR(MR)
Layer 1
223
226
222
225
227
221
228
224

Fig. 14

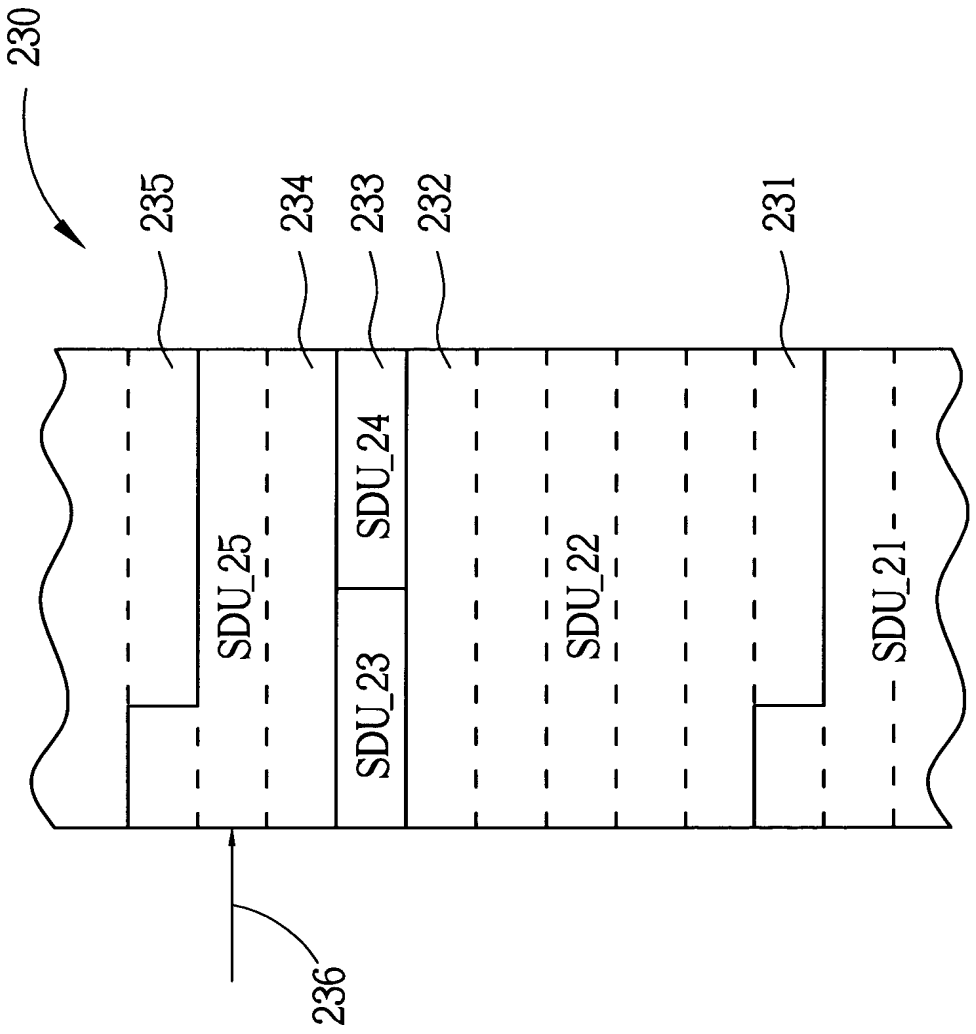

Fig. 15

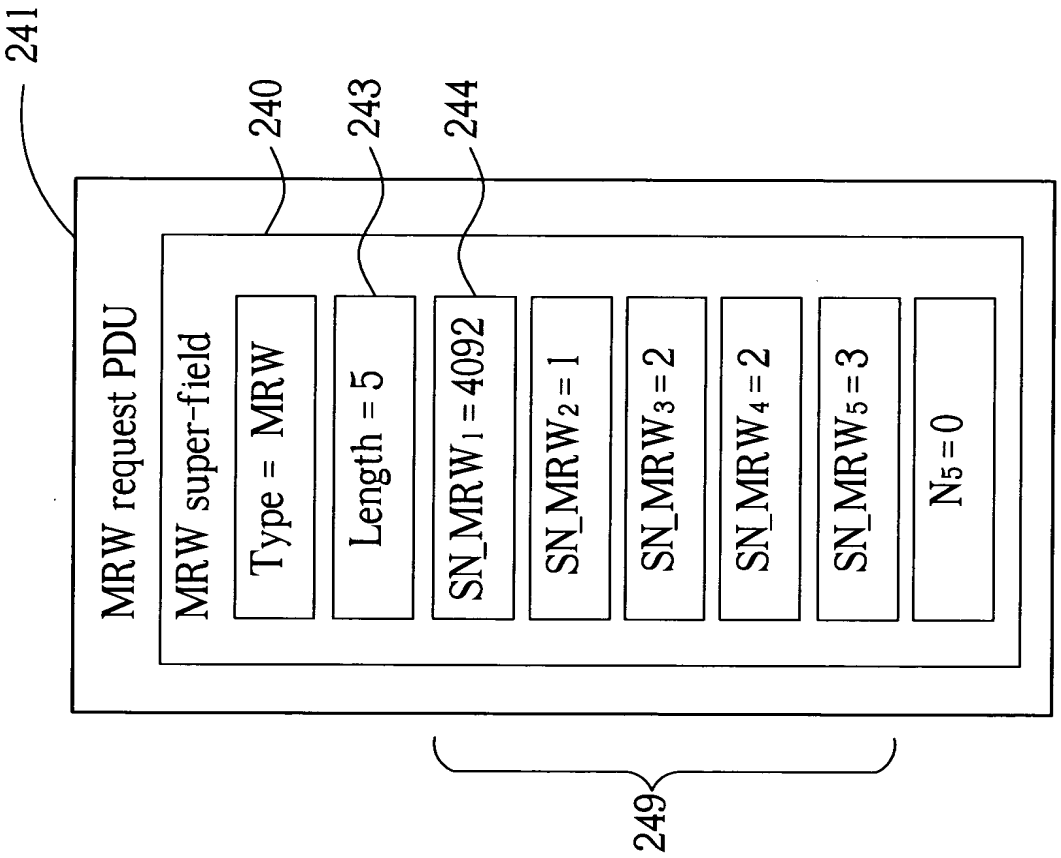
241
240
243
244
MRW request PDU
MRW super-field
Type = MRW
Length = 5
SN_MRW1 = 4092
SN_MRW2 = 1
SN_MRW3 = 2
SN_MRW4 = 2
SN_MRW5 = 3
N5 = 0
249

Fig. 16

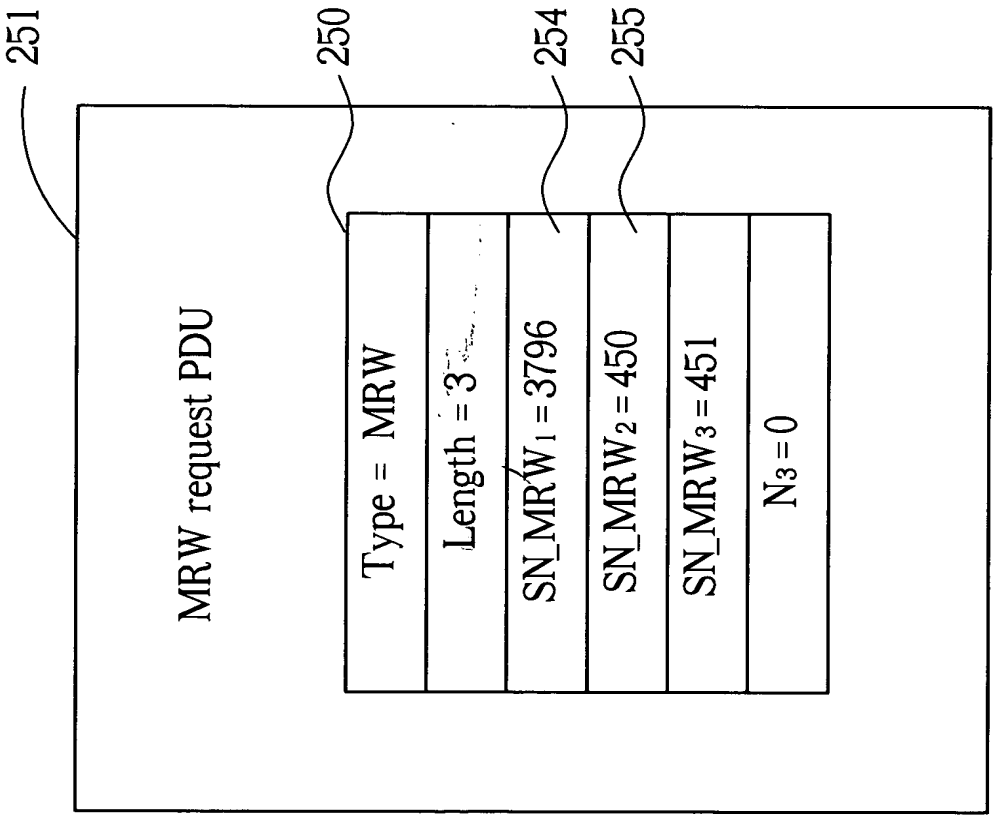
251
250
254
255
MRW request PDU
Type = MRW
Length = 3
SN_MRW1 = 3796
SN_MRW2 = 450
SN_MRW3 = 451
N3 = 0

Fig. 17

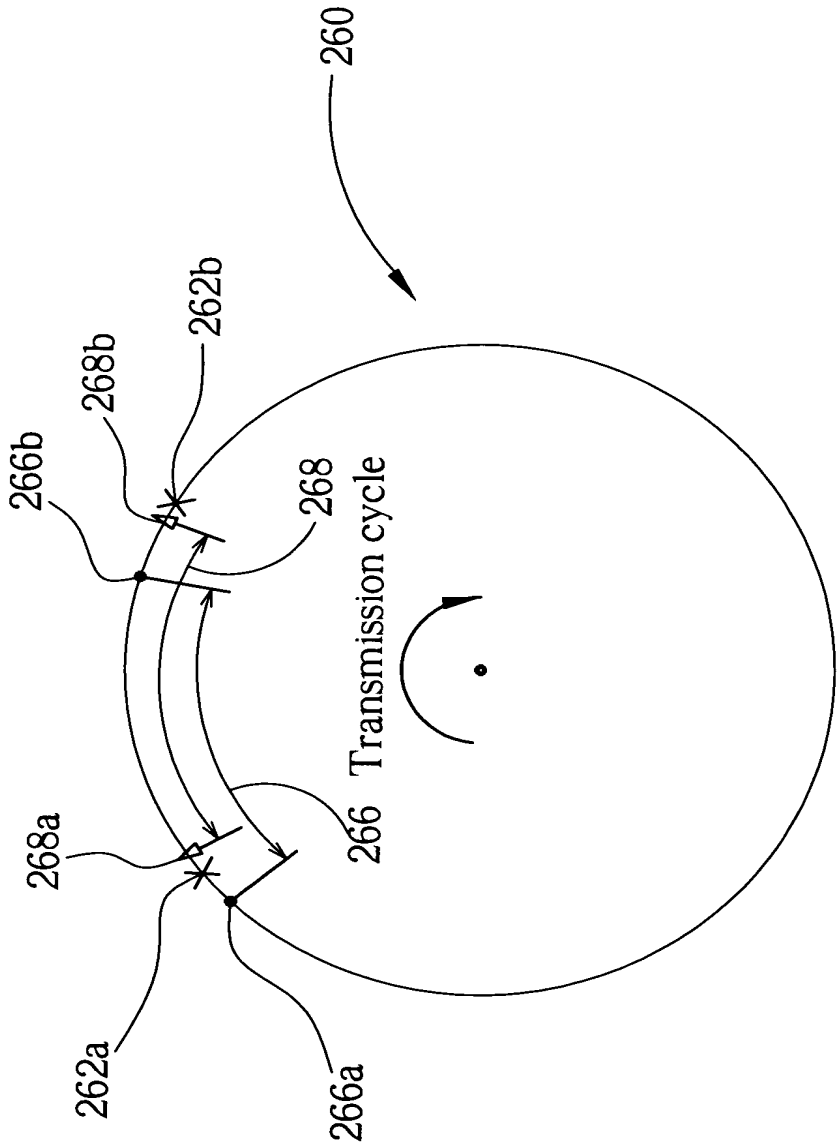
260
262b
268b
266b
268
Transmission cycle
266
268a
262a
266a

Fig. 18

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* ASTP0011PCT

Box No. I TITLE OF INVENTION

Determination of acceptable sequence number ranges in a communications protocol

Box No. II APPLICANT ☐ This person is also inventor

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

ASUSTeK COMPUTER INC.
4F, No.150, Li-Te Rd., Peitou,
Taipei City, Taiwan, R.O.C.

Telephone No. +886-2-2894-3447

Facsimile No.

Teleprinter No.

Applicant's registration No. with the Office

State *(that is, country)* of nationality: Republic of China

State *(that is, country)* of residence: Republic of China

This person is applicant for the purposes of: ☒ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

ASUS COMPUTER INTERNATIONAL
6737 Mowry Ave., Mowry Business Center,
Building 2 Newark, CA 94560, U.S.A.

This person is:
☒ applicant only
☐ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality: United States of America

State *(that is, country)* of residence: United States of America

This person is applicant for the purposes of: ☒ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

Winston Hsu,
5F, No.389, Fu-Ho Rd.,
234 Yungho City, Taipei Hsien,
Taiwan, R.O.C.

Telephone No. +886-2-8923-7350

Facsimile No. +886-2-8923-7390

Teleprinter No.

Agent's registration No. with the Office 41,526

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

Sam Shiaw-Shiang Jiang
No.25, Alley 23, Lane 473, Nan-Ta Rd.,
Hsin-Chu City, Taiwan, R.O.C.

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality: Republic of China

State *(that is, country)* of residence: Republic of China

This person is applicant for the purposes of: ☒ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

Alex Chung-Ming Sun
3F, No.3, Lane 10, Guo-Tai St.,
Chung-Li City, Taiwan, R.O.C.

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality: Republic of China

State *(that is, country)* of residence: Republic of China

This person is applicant for the purposes of: ☒ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES *Mark the applicable check-boxes below; at least one must be marked.*

The following designations are hereby made under Rule 4.9(a):

Regional Patent

☐ **AP** **ARIPO Patent:** **GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **MZ** Mozambique, **SD** Sudan, **SL** Sierra Leone, **SZ** Swaziland, **TZ** United Republic of Tanzania, **UG** Uganda, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

☐ **EA** **Eurasian Patent:** **AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakhstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☒ **EP** **European Patent:** **AT** Austria, **BE** Belgium, **CH & LI** Switzerland and Liechtenstein, **CY** Cyprus, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **SE** Sweden, **TR** Turkey, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☐ **OA** **OAPI Patent:** **BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Côte d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **GW** Guinea-Bissau, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

☐ **AE** United Arab Emirates
☐ **AG** Antigua and Barbuda
☐ **AL** Albania
☐ **AM** Armenia
☐ **AT** Austria
☐ **AU** Australia
☐ **AZ** Azerbaijan
☐ **BA** Bosnia and Herzegovina
☐ **BB** Barbados
☐ **BG** Bulgaria
☐ **BR** Brazil
☐ **BY** Belarus
☐ **BZ** Belize
☐ **CA** Canada
☐ **CH & LI** Switzerland and Liechtenstein
☒ **CN** China
☐ **CO** Colombia
☐ **CR** Costa Rica
☐ **CU** Cuba
☐ **CZ** Czech Republic
☒ **DE** Germany
☐ **DK** Denmark
☐ **DM** Dominica
☐ **DZ** Algeria
☐ **EE** Estonia
☐ **ES** Spain
☒ **FI** Finland
☒ **GB** United Kingdom
☐ **GD** Grenada
☐ **GE** Georgia
☐ **GH** Ghana
☐ **GM** Gambia
☐ **HR** Croatia
☐ **HU** Hungary
☐ **ID** Indonesia
☐ **IL** Israel
☐ **IN** India
☐ **IS** Iceland
☒ **JP** Japan
☐ **KE** Kenya
☐ **KG** Kyrgyzstan
☐ **KP** Democratic People's Republic of Korea
☒ **KR** Republic of Korea
☐ **KZ** Kazakhstan
☐ **LC** Saint Lucia
☐ **LK** Sri Lanka
☐ **LR** Liberia
☐ **LS** Lesotho
☐ **LT** Lithuania
☐ **LU** Luxembourg
☐ **LV** Latvia
☐ **MA** Morocco
☐ **MD** Republic of Moldova
☐ **MG** Madagascar
☐ **MK** The former Yugoslav Republic of Macedonia
☐ **MN** Mongolia
☐ **MW** Malawi
☐ **MX** Mexico
☐ **MZ** Mozambique
☐ **NO** Norway
☐ **NZ** New Zealand
☐ **PL** Poland
☐ **PT** Portugal
☐ **RO** Romania
☐ **RU** Russian Federation
☐ **SD** Sudan
☒ **SE** Sweden
☐ **SG** Singapore
☐ **SI** Slovenia
☐ **SK** Slovakia
☐ **SL** Sierra Leone
☐ **TJ** Tajikistan
☐ **TM** Turkmenistan
☐ **TR** Turkey
☐ **TT** Trinidad and Tobago
☐ **TZ** United Republic of Tanzania
☐ **UA** Ukraine
☐ **UG** Uganda
☐ **US** United States of America
☐ **UZ** Uzbekistan
☐ **VN** Viet Nam
☐ **YU** Yugoslavia
☐ **ZA** South Africa
☐ **ZW** Zimbabwe

Check-boxes below reserved for designating States which have become party to the PCT after issuance of this sheet:

☐ ..... ☐ ..... ☐ .....
☐ ..... ☐ ..... ☐ .....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)*

Box No. VI PRIORITY CLAIM

The priority of the following earlier application(s) is hereby claimed:

Filing date of earlier application *(day/month/year)*	Number of earlier application	Where earlier application is:		
		national application: country	regional application:* regional Office	international application: receiving Office
item (1) 09/02/2001	09/779,490	USA		
item (2)				
item (3)				
item (4)				
item (5)				

☐ Further priority claims are indicated in the Supplemental Box.

The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of this international application is the receiving Office)* identified above as:

☐ all items ☐ item (1) ☐ item (2) ☐ item (3) ☐ item (4) ☐ item (5) ☐ other, see Supplemental Box

** Where the earlier application is an ARIPO application, indicate at least one country party to the Paris Convention for the Protection of Industrial Property or one Member of the World Trade Organization for which that earlier application was filed (Rule 4.10(b)(ii)):* . . . .

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)*:

ISA / US

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority)*:

Date *(day/month/year)* Number Country *(or regional Office)*

Box No. VIII DECLARATIONS

The following **declarations** are contained in Boxes Nos. VIII (i) to (v) *(mark the applicable check-boxes below and indicate in the right column the number of each type of declaration)*: Number of declarations

☐	Box No. VIII (i)	Declaration as to the identity of the inventor	:
☐	Box No. VIII (ii)	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	:
☐	Box No. VIII (iii)	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	:
☐	Box No. VIII (iv)	Declaration of inventorship (only for the purposes of the designation of the United States of America)	:
☐	Box No. VIII (v)	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	:

Box No. IX CHECK LIST; LANGUAGE OF FILING

This international application **contains**:

(a) the following number of **sheets in paper form**:

request (including declaration sheets)	:	7
description (excluding sequence listing part)	:	18
claims	:	4
abstract	:	1
drawings	:	9
Sub-total number of sheets	:	39
sequence listing part of description *(actual number of sheets if filed in paper form, whether or not also filed in computer readable form; see (b) below)*	:	0
Total number of sheets	:	39

(b) sequence listing part of description filed in **computer readable form**

(i) ☐ only (under Section 801(a)(i))

(ii) ☐ in addition to being filed in paper form (under Section 801(a)(ii))

Type and number of carriers (diskette, CD-ROM, CD-R or other) on which the sequence listing part is contained *(additional copies to be indicated under item 9(ii), in right column)*: .....

This international application is **accompanied by** the following item(s) *(mark the applicable check-boxes below and indicate in right column the number of each item)*:

		Number of items
1. ☒ fee calculation sheet	:	1
2. ☒ original separate power of attorney	:	1
3. ☐ original general power of attorney	:	
4. ☐ copy of general power of attorney; reference number, if any:	:	
5. ☐ statement explaining lack of signature	:	
6. ☒ priority document(s) identified in Box No. VI as item(s): (1)	:	
7. ☐ translation of international application into *(language)*:	:	
8. ☐ separate indications concerning deposited microorganism or other biological material	:	
9. ☐ sequence listing in computer readable form (indicate also type and number of carriers (diskette, CD-ROM, CD-R or other))		
(i) ☐ copy submitted for the purposes of international search under Rule 13*ter* only (and not as part of the international application)	:	
(ii) ☐ *(only where check-box (b)(i) or (b)(ii) is marked in left column)* additional copies including, where applicable, the copy for the purposes of international search under Rule 13*ter*	:	
(iii) ☐ together with relevant statement as to the identity of the copy or copies with the sequence listing part mentioned in left column	:	
10. ☒ other *(specify)*: declaration, assignment papers	:	

Figure of the drawings which should accompany the abstract:

Language of filing of the international application: English

Box No. X SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

Winston Hsu 6/2/2002

Winston Hsu, Paten Agent
Reg. No. : 41,526

For receiving Office use only

1. Date of actual receipt of the purported international application:	2. Drawings: ☐ received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date of timely receipt of the required corrections under PCT Article 11(2):	☐ not received:
5. International Searching Authority (if two or more are competent): ISA /	6. ☐ Transmittal of search copy delayed until search fee is paid

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

PATENT
Docket No. ASTP0011PCT

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

I believe I am the sole (if only one name appears below), or a joint (if more than one name appears), original and first inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:
" Determination of acceptable sequence number ranges in a communications protocol "

\+ The specification for the above entitled invention is filed herewith.

_____The specification for the above entitled invention was filed previously with application serial number: _____ Filing Date: _____

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of the invention disclosed in this application in accordance with Title 37, Code of Federal Regulations, Section 1.56 (a). I further acknowledge the duty in any continuation-in-part application to disclose to the Patent and Trademark Office all information known to be material to the patentability of the invention disclosed in this application, as defined in 1.56, which became available to me between the filing date of the prior application and the filing date of this application.

PRIORITY CLAIM

_____There is no claim of priority.

\+ Claim of priority is based on the following:

Filing No. in U.S.A.: 09/779,490

Filing Date in U.S.A.: 2001/2/9

POWER OF ATTORNEY

As a named inventor, I hereby appoint the following attorney to prosecute this application and to transact all related business in the Patent and Trademark Office:

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DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements mad on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued hereon.

Date: Dec. 26, 2001 Sam Shiaw-Shiang Jiang

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PATENT

Docket No.: ASTP0011PCT

10/019645

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

RECORDING COVER SHEET

1. Assignor: Sam Shiaw-Shiang Jiang, Alex Chung-Ming Sun
2. Assignee: 1) ASUSTeK COMPUTER INC.
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3. Nature of Conveyance: Assignment of patent
4. Reference number: Application filed herewith.
5. Correspondence to: Winston Hsu
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6. Number of applications affected by this recording: 1
   Total fee: (1x $ 40) = $ 40.00
   Authorization is hereby given to charge the over payment to deposit account #500801
7. Execution date of the document to be recorded: 12/26/2001
8. Total number of pages including cover sheet: 3
9. I declare under penalty of perjury that to the best of my knowledge and belief, the information contained on this cover sheet is true and correct, and that any copy submitted herewith is a true and correct copy of the original document.

Date: 1/2/2002 Winston Hsu

Winston Hsu
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PATENT

ASSIGNMENT OF INVENTION

In consideration of the payment by ASSIGNEE to ASSIGNOR of the sum of One Dollar ($1.00), the receipt of which is hereby acknowledged, and for other good and valuable consideration,

ASSIGNORS (Inventors):

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Name: _____ Nationality: _____
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Name: _____ Nationality: _____
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Hereby sells, assigns and transfers to (1) **ASUSTeK COMPUTER INC.** and (2) **ASUS COMPUTER INTERNATIONAL** (hereinafter "Assignee"), of (Assignee address) (1) **4F, No.150, Li-Te Rd., Peitou, Taipei City, Taiwan, R.O.C.** and (2) **6737 Mowry Ave. Mowry Business Center, Building 2 Newark, CA 94560, USA** and the successors assigns and legal representatives of the ASSIGNEE the entire right, title, and interest in and to any and all improvements which are disclosed in the invention entitled: " Determination of acceptable sequence number ranges in a communications protocol "

Which is found in :

(a) _____ U.S. patent application executed on even date herewith
(b) _____ U.S. patent application executed on _____
(c) _____ U.S. application serial no. _____
(d) _____ patent no. _____ issued _____

and, in and to, all Letters Patent to be obtained for said invention by the above application or ant continuation, division, renewal, or substitute thereof, and as to letters patent any reissue or re-examination thereof

ASSIGNOR hereby covenants that no assignment, sale, agreement or encumbrance has been or will be made or entered into which would conflict with this assignment;

ASSIGNOR further covenants that ASSIGNEE will, upon its request, be provided promptly with all pertinent facts and documents relating to said invention and said Letters Patent and legal equivalents as may be known and accessible to ASSIGNOR and will testify as to the same in any interference, litigation or proceeding related thereto and will promptly execute and deliver to ASSIGNEE or its legal representatives any and all papers, instruments or affidavits required to apply for, obtain, maintain, issue and enforce said application, said invention and said Letters Patent and said equivalents thereof which may be necessary or desirable to carry out the proposes thereof.

IN WITNESS WHEREOF, We have hereunto set hand and seal this Dec 26, 2001 (Date of signing).

(Type name of inventor)	**Signature of INVENTOR**
Sam Shiaw-Shiang Jiang	Sam Shiaw-Shiang Jiang
Alex Chung-Ming Sun	2001-12-26

This sheet is not part of and does not count as a sheet of the international application.

PCT

FEE CALCULATION SHEET

Annex to the Request

For receiving Office use only

International Application No.

Date stamp of the receiving Office

Applicant's or agent's file reference: ASTP0011PCT

Applicant: ASUSTeK COMPUTER INC., ASUS COMPUTER INTERNATIONAL, Sam Shiaw-Shiang Jiang, Alex Chung-Ming Sun

CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE . . . . . 240 [T]

2. SEARCH FEE . . . . . 450 [S]

International search to be carried out by US

(If two or more International Searching Authorities are competent to carry out the international search, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FEE

Basic Fee

Where item (b) of Box No. IX applies, enter **Sub-total number of sheets**
Where item (b) of Box No. IX does not apply, enter **Total number of sheets** } 39

[b1] first 30 sheets . . . . . 382 [b1]

[b2] 9 (number of sheets in excess of 30) x 9 (fee per sheet) = 81 [b2]

[b3] additional component (only if sequence listing part of description is filed in computer readable form under Section 801(a)(i), or both in that form and on paper, under Section 801(a)(ii)):

400 x _____ (fee per sheet) = 0 [b3]

Add amounts entered at b1, b2 and b3 and enter total at B . . . . 463 [B]

Designation Fees

The international application contains 6 designations.

6 (number of designation fees payable *(maximum 6)*) x 82 (amount of designation fee) = 492 [D]

Add amounts entered at B and D and enter total at I . . . . . 955 [I]

(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 25% of the sum of the amounts entered at B and D.)

4. FEE FOR PRIORITY DOCUMENT *(if applicable)* . . . . . 0 [P]

5. TOTAL FEES PAYABLE . . . . . 1645 TOTAL

Add amounts entered at T, S, I and P, and enter total in the TOTAL box

☐ The designation fees are not paid at this time.

MODE OF PAYMENT

☒ authorization to charge deposit account (see below) ☐ postal money order ☐ cash ☐ coupons

☐ cheque ☐ bank draft ☐ revenue stamps ☐ other *(specify)*:

AUTHORIZATION TO CHARGE (OR CREDIT) DEPOSIT ACCOUNT

(This mode of payment may not be available at all receiving Offices)

Receiving Office: RO/ US

Deposit Account No.: 50-0801

Date: 6/2/2002

Name: Winston Hsu

Signature: Winston Hsu

☒ Authorization to charge the total fees indicated above.

☒ *(This check-box may be marked only if the conditions for deposit accounts of the receiving Office so permit)* Authorization to charge any deficiency or credit any overpayment in the total fees indicated above.

☐ Authorization to charge the fee for priority document.

DETERMINATION OF ACCEPTABLE SEQUENCE NUMBER RANGES IN A COMMUNICATIONS PROTOCOL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a wireless communications protocol. More specifically, the present invention discloses a method for determining acceptable sequence number ranges in a transmission time interval.

2. Description of the Prior Art

The surge in public demand for wireless communication devices has placed pressure upon industry to develop increasingly sophisticated communications standards. The 3rd Generation Partnership Project (3GPP™) is an example of such a new communications protocol. Such standards utilize a three-layer approach to communications. Please refer to Fig.1. Fig.1 is a block diagram of the three layers in a communications protocol. In a typical wireless environment, a first station 10 is in wireless communications with one or more second stations 20. An application 13 on the first station 10 composes a message 11 and has it delivered to the second station 20 by handing the message 11 to a layer 3 interface 12. The layer 3 interface 12 may also generate some layer 3 signaling messages 12a for the purpose of controlling layer 3 operations. An example of such a layer 3 signaling message is a request for ciphering key changes, which are generated by the layer 3 interfaces 12 and 22 of both the first and the second stations, respectively. The layer 3 interface 12 delivers either the message 11 or the layer 3 signaling message 12a to a layer 2 interface 16 in the form of layer 2 service data units (SDUs) 14. The layer

2 SDUs 14 may be of any length. The layer 2 interface 16 composes the SDUs 14 into one or more layer 2 protocol data units (PDUs) 18. Each layer 2 PDU 18 is of a fixed length, and is delivered to a layer 1 interface 19. The layer 1 interface 19 is the physical layer, transmitting data to the second station 20. The transmitted data is received by the layer 1 interface 29 of the second station 20 and reconstructed into one or more PDUs 28, which are passed up to the layer 2 interface 26. The layer 2 interface 26 receives the PDUs 28 and builds up one or more layer 2 SDUs 24. The layer 2 SDUs 24 are passed up to the layer 3 interface 22. The layer 3 interface 22, in turn, converts the layer 2 SDUs 24 back into either a message 21, which should be identical to the original message 11 that was generated by the application 13 on the first station 10, or a layer 3 signaling message 22a, which should be identical to the original signaling message 12a generated by the layer 3 interface 12 and which is then processed by the layer 3 interface 22. The received message 21 is passed to an application 23 on the second station 20.

Of particular interest is the layer 2 interface, which acts as a buffer between the relatively high-end data transmission and reception requests of the layer 3 interfaces 12 and 22, and the low-level requirements of the physical transmission and reception process at the layer 1 interfaces 19 and 29. Please refer to Fig.2. Fig.2 is a simplified diagram of a transmission/reception process from a layer 2 perspective. The layer 2 interface 32 of a first station 30 receives a string of SDUs 34 from the layer 3 interface 33. The layer 2 SDUs 34 are sequentially ordered from 1 to 5, and are of an unequal length. The layer 2 interface 32 converts the string of SDUs 34 into a string of layer 2 PDUs 36. The layer 2 PDUs 36 are

sequentially ordered from 1 to 4, and are usually all of an equal length. The string of layer 2 PDUs 36 is then sent off to the layer 1 interface 31 for transmission. A reverse process occurs at the second station 40, with the second station 40 layer 2 interface 42 converting a received string of layer 2 PDUs 46 into a received string of layer 2 SDUs 44, which are then passed up to a layer 3 interface 43. There are two delivery modes: in-sequence delivery and out-of-sequence delivery. If the established connection between the first station 30 and the second station 40 is configured to be in the in-sequence delivery mode, the multi-layered protocol insists that the layer 2 interface 42 present the SDUs 44 to the layer 3 interface 43 in order. That is, the layer 2 interface 42 must present the layer 2 SDUs 44 to the layer 3 interface 43 in the sequential order of the SDUs 44, beginning with SDU 1 and ending with SDU 5. The ordering of the SDUs 44 may not be scrambled, nor may a subsequent SDU 44 be delivered to the layer 3 interface 43 until all of the prior SDUs 44 have been delivered. However, if the established connection is configured to be in the out-of-sequence delivery mode, the layer 2 interface 42 can present the layer 2 SDUs 44 to the layer 3 interface 43 out of sequential order.

In line transmissions, such requirements are relatively easy to fulfill. In the noisy environment of wireless transmissions, however, the second station 40 often misses data. Additionally, under some transmission modes, the layer 2 interface 32 of the first station 30 may actually discard some of the layer 2 SDUs 34 or layer 2 PDUs 36 after a predetermined amount of time if the layer 2 SDUs 34 or PDUs 36 have not been transmitted. Some layer 2 PDUs in the received string of layer 2 PDUs 46 will therefore be missing, either due to deliberate

discarding from the transmitting side, or from improper reception on the receiver side. Ensuring that the layer 3 SDUs 44 are presented in order, when the system is in the in-sequence delivery mode, can thus pose a significant challenge. Even in the out-of sequence delivery mode, a layer 2 SDU 44 cannot be presented until all of its composing layer 2 PDUs 46 have been correctly received. The format of the layer 2 PDUs 36, 46 is thus carefully considered to help overcome these obstacles.

Generally speaking, there are two broad modes for transmitting and receiving data: acknowledged mode, and unacknowledged mode. For acknowledged mode data, the second station 40 sends a special acknowledging signal to the first station 30 to indicate successfully received layer 2 PDUs 46. No such signaling is performed for unacknowledged mode data. For purposes of the present discussion, only the unacknowledged mode of data transmission and reception is considered. Please refer to Fig.3 in conjunction with Fig.2. Fig.3 is a block diagram of an unacknowledged mode data (UMD) PDU 50, as defined by the 3GPP™ TS 25.322 specification. The UMD PDU 50 is used to transmit unacknowledged mode SDU data from the layer 3 interface 33 of the first station 30, which is then received and reassembled by the second station 40 and presented to the layer 3 interface 43 as the layer 2 SDUs 44. That is, layer 2 UMD PDUs 36, 46 are used to carry the layer 2 SDUs 34, 44 that originate from the layer 3 interfaces 33, 43. The UMD PDU 50 is divided into several fields, as defined by the layer 2 protocol. The first field 51 is a sequence number (SN) field, and is seven bits long. Successive UMD PDUs have successively higher sequence numbers, and in this way a receiver can properly reassembled UMD PDUs 46 to form the SDUs 44. That is, if a

UMD PDU 36 is transmitted with a sequence number value equal to 19, the next UMD PDU 36 would be transmitted with a sequence number value equal to 20, and so forth. The next field, 52a, is an extension bit, and when set indicates the presence of a following length indicator (LI). An LI may be either 7 bits long or 15 bits long, and is used to indicate the ending position of an SDU within the UMD PDU 50. If a single SDU completely fills the data region 58 of the UMD PDU 50, then the extension bit 52a would be zero, thereby indicating that no LI is present. In the example UMD PDU 50, however, there are at least two SDUs ending in the PDU 50: SDU_1 57a, and SDU_2 57b. There must, therefore, be two LIs to indicate the respective ends of the SDU_1 57a and the SDU_2 57b. A UMD PDU following the UMD PDU 50 would hold the LI for SDU_3 57c. The first LI, LI_1, is in field 56a following the extension bit field 52a, and marks the end of the SDU_1 57a. LI_1 56a has an extension bit 52b that is set, indicating the presence of another LI, LI_2 in field 56b. LI_2 56b indicates the ending position of the SDU_2 57b, and has an extension bit 52c that is cleared, signifying that there are no more LIs, and that the data region 58 is thus beginning. The data region is used to carry the SDUs 57a, 57b, 57c.

Please refer to Fig.4 in conjunction with Fig.5. Fig.4 is a more detailed block diagram of a prior art layer 2 interface 60. Fig.5 is a timing diagram of transmission time intervals (TTIs) 72. The layer 2 interface 60 comprises a radio link control (RLC) layer 62 on top of, and in communications with, a medium access control (MAC) layer 64. The MAC layer 64 acts as an interface between the RLC layer 62 and the layer 1 interface 61. The MAC layer 64 divides the transmission of PDUs 63, which the MAC layer 64 receives from the RLC layer 62, into a series

of transmission time intervals (TTIs) 72. Each TTI 72 has an interval length that is identical to the other TTIs 72, such as a 20 milliseconds (ms) interval. Within the time span of each TTI 72, the MAC layer 64 sends off a set of transport blocks 74 to the layer 1 interface 61 to be transmitted. The set of transport blocks 74 comprises a predetermined number of transport blocks 74a. Each of the transport blocks 74a comprises one RLC PDU 75 and may optionally carry a MAC header 76. All of the RLC PDUs 75 and, thus, the transport blocks 74a within each TTI 72 are of the same length. The number of RLC PDUs 75 (or transport blocks 74a) within each transport block set 74 between TTIs 72 may change. For example, in Fig.5 the first TTI 72 transmits six PDUs 75, and the subsequent TTI 72 transmits three PDUs 75. The actual data length of the PDUs 75 may also vary from TTI 72 to TTI 72, but is always the same within each TTI 72. Consequently, prior to transmission for each TTI 72, the MAC layer 64 informs the RLC layer 62 of the number of PDUs 75 required for the TTI 72, and the size for the PDUs 75 within the TTI 72. The RLC layer 62 composes SDUs 65a, held in a buffer 65, into appropriately sized PDUs, and delivers the required number of PDUs 63 to the MAC layer 64. As noted, the MAC layer may optionally add a MAC header 76 to each RLC PDU 75 to generate the transport blocks 74a for the transport block set 74, and then the transport block set 74 of PDUs 74 is sent off to the layer 1 interface 61 for transmission.

For purposes of security, PDUs 63, 75 are encrypted before being delivered to the layer 1 interface 61. The encryption is usually performed in either the MAC layer 64 or the RLC layer 62. For purposes of the present discussion, it will be assumed that encryption of the PDUs 63, 75 occurs in the RLC

layer 62. Prior to delivering PDUs 63 to the MAC layer 64, an encryption engine 66 encrypts all but the first octet of data within each PDU 63, 75, and delivers encrypted PDUs 63 to the MAC layer 64. As the first octet of each PDU 63, 75 is not encrypted, the sequence number 51 (from Fig.3) is transmitted in an unencrypted state. The reason for this is that the encryption engine 66 uses the sequence number 51 of each PDU 63, 75 to generate the encrypted PDUs 63, 75. Consequently, on the receiver side, the sequence number 51 must be made available to perform the decryption of the PDUs 75. The sequence number 51 of each PDU is used to form a count-c value 66c. The count-c value 66c is a 32-bit number that comprises a hyper-frame number (HFN) 66h as the most significant 25 bits, and the sequence number 51 of the PDU 63, 75 to be encrypted as the least significant 7 bits 66s. The HFN 66h is initially zero, but is incremented upon detection of rollover in the PDU 63, 75 sequence numbers 51. For example, if the HFN 66h has a value of zero, and a PDU 63, 75 has a sequence number value 51 of 127, count-c 66c would have a value of 127 that is used to encrypt the PDU 63, 75. A subsequent PDU 63, 75 would have a sequence number value 51 of zero, due to rollover, and the encryption engine 66 would thus increment the HFN value 66h to one. Count-c, used to encrypt this subsequent PDU 63, 75, would thus be 128. The sequence number values 66s are transmitted with the respective PDUs 75, as they are unencrypted. The HFN value 66h, however, is not transmitted, and thus must remain synchronized on both the reception and transmission sides for the PDUs 75 to be properly decrypted.

Please refer to Fig.6 in conjunction with Fig.4. Fig.6 is a diagram of transmission and reception of PDUs 82 and 92. PDUs 82, each with an indicated sequence number (SN) value,

are transmitted from a transmission side 80. The PDUs 82 are then received on a receiver side 90 and assembled into PDUs 92, each with an indicated sequence number (SN). The transmission side 80 sends a first block of PDUs 82 with sequence numbers incrementing from 110 to 112. The transmission side then discards PDUs 82 with sequence numbers ranging from 113 to 125, indicated by the Xs 83, and continues transmitting with sequence number values from 126 to 1. Rollover of the 7-bit sequence numbers occurs after a value of 127. Again, PDUs 82 are discarded that have sequence number values from 2 to 19, indicated by Xs 84, and then transmission continues with PDUs 82 having sequence number values incrementing from 20 to 23. More PDUs 82 are discarded, indicated by Xs 85, and transmission resumes with PDUs 82 having sequence number values beginning at 30. Discarding of the PDUs 83, 84 and 85 may occur at the transmission side 80 due to time-out errors, or for other reasons. The receiving side 90, however, is not directly informed of these PDU discards 83, 84 and 85, and infers them from the non-sequentiality of the sequence numbers in the received PDUs 92. For example, between received PDUs 93a and 93b, the receiving side 90 infers that the PDUs 83 have been discarded, and must react accordingly to properly reassemble the PDUs 92 into correct SDUs. At received PDU 96b, rollover occurs in the sequence numbers, and so the receiving side 90 increments its HFN 66h accordingly. Received PDU 96b thus uses a different HFN 66h for decryption than received PDU 96a. This is proper, as it tracks the HFNs 66h of the corresponding transmitted PDUs 86a and 86b. As noted previously, the synchronization of the HFN number 66h on the transmission side 80 with the reception side 90 is of critical importance for the proper decryption of the received PDUs 92.

Unfortunately, the transmission process is not error-free. PDUs 82 can get lost or corrupted. For example, on the reception side 90, a PDU 97 is received with an erroneous sequence number value of 100, instead of the correct sequence number value of 23 for the correspondingly transmitted PDU 87. A layer 1 circular redundancy check (CRC) should generally detect errors in the received PDUs 92 and discard any found to be corrupted. However, it is possible for some corrupted PDUs 92 to avoid detection, and, for the present example, we may imagine that the corrupted PDU 97 has been damaged in such a way as to result in the incorrect sequence number value of 100. On the reception side 90, we may imagine that the encryption engine 66 uses an HFN value of one to decrypt the PDU 98a. This is the same HFN value 66h that was used on the transmission side 80 to encrypt the PDU 88a, and so the received PDU 98a is properly decrypted. The corrupted PDU 97 will not be properly decrypted, however, as its sequence number value of 100 does not correspond to the sequence number value of 23 that was used to encrypt the transmitted PDU 87. The RLC layer 62 on the reception side will also assume that PDUs 82 with sequence number values ranging from 23 to 99 were discarded by the transmission side 80. This is incorrect. Worse still, though, is that upon reception of the PDU 98b, the encryption engine 66 on the reception side 90 will incorrectly assume that PDUs 82 on the transmission side 80 with sequence number values ranging from 101 to 127 and zero to 29 were discarded prior to transmission, or were lost in transmission. The encryption engine 66 on the reception side 90 will thus assume that rollover of the sequence numbers has occurred and increment its HFN value 66h accordingly. The reception-side 90 HFN value 66h will thus go from a value of one to a value of two. When the reception side 90 attempts to decrypt the received PDU 98b, an HFN 66h value of two will

be used, which is out of synch with the HFN value 66h of one used on the transmission side 80. The PDU 98b will thus be improperly decrypted, resulting in a meaningless PDU 92. Additionally, as the HFN values 66h on the transmission side 80 and reception side 90 are no longer synchronized, all subsequent received PDUs 92 will also be improperly decrypted. The communications channel between the reception side 90 and transmission side 80 is effectively destroyed.

SUMMARY OF THE INVENTION

It is therefore a primary objective of this invention to provide a method for determining acceptable ranges of received sequence numbers in a wireless communications protocol.

Briefly summarized, the preferred embodiment of the present invention discloses a method for determining acceptable ranges of received sequence numbers in a wireless communications protocol. The wireless communications protocol utilizes protocol data units (PDUs) for transmitting and receiving service data units (SDUs). Each PDU has a sequence number of n bits for indicating a relative sequential ordering of the PDU in a transmitted or received stream of PDUs. A transmission time interval (TTI) is also used in which a predetermined number of PDUs are transmitted or received. PDUs are received within a TTI. A starting sequence number and an ending sequence number for received PDUs within the TTI are found. Any received PDU within the TTI that has a sequence number that is sequentially before the starting sequence number or that is sequentially after the ending sequence number is discarded.

It is an advantage of the present invention that by discarding

PDUs in the TTI that have sequence number values that are not within the range of the starting and ending sequence numbers, loss of synchronization in the hyper-frame numbers between transmitting and receiving stations is avoided. Additionally, the discarding of such PDUs helps to prevent the passing up to higher layers of corrupted data.

These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment, which is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a block diagram of a three-layer communications protocol.

Fig.2 is a simplified diagram of a transmission/reception process from a layer 2 perspective.

Fig.3 is a block diagram of an unacknowledged mode data (UMD) protocol data unit (PDU).

Fig.4 is a more detailed block diagram of a prior art layer 2 interface.

Fig.5 is a timing diagram of transmission time intervals (TTIs).

Fig.6 is a diagram of transmission and reception of PDUs according to the prior art.

Fig.7 is a diagram of transmission and reception of PDUs according to the present invention.

Fig.8 is a block diagram of a present invention layer 2 interface.

Fig.9 is a block diagram of an example PDU according to

the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In the following description, a communications protocol as disclosed in the 3GPP™ specification TS 25.322, V3.5.0, is used by way of example. However, it should be clear to one in the art that any wireless communications protocol that suffers from data corruption of received protocol data units (PDUs) may utilize the discarding method of the present invention. It should be further noted that a station in the following description could be both a transmitter and receiver of information. Such a station might be a cellular telephone, a personal data assistant (PDA), a personal computer (PC), or any other device that utilizes the wireless communications protocol.

It is the method of the present invention to ensure that all received protocol data units (PDUs) within a transmission time interval (TTI) have sequence number (SN) values that are sequentially within a predetermined range for the TTI. Please refer to Fig.7 and Fig.8. Fig.7 is a diagram of transmission and reception of PDUs 113 and 123 according to the present invention. Fig.8 is a block diagram of a layer 2 transmission/reception interface 100 of the present invention. Except where noted, PDUs, service data units (SDUs) and TTIs of the present invention are as described in the Description of the Prior Art. Additionally, encryption of the PDUs, and the use of hyper-frame numbers (HFNs) and sequence numbers for the encryption/decryption process are as described in the prior art. To illustrate the method of the present invention, a simple example is presented. A layer 2 interface 100 on a

transmission side 110 receives a string of SDUs 105a from a layer 3 interface 103. The SDUs 105a are held in a buffer 105, awaiting transmission. Due to time-out, some of the SDUs 105a are discarded, and hence are never transmitted. The medium access control (MAC) layer 104 informs the radio link control (RLC) layer 102 of the number and size of PDUs 113 for an impending TTI 112. For the present example, we assume that the TTI 112 is to deliver nine PDUs 113. The last sequence number used in a previous TTI 111 on the transmission side 110 held a value of 123. The RLC layer 102 thus increments the value of 123 by one to obtain a value of 124 for the sequence number of the first PDU 113a in the impending TTI 112. Successive PDUs 113 have incrementally higher sequence number values, regardless of whether or not SDUs 105a were discarded between successive PDUs 113. That is, each successive PDU 113 in the TTI 112 has a sequence number value that is always one higher than the previous PDU 113. Thus, the PDU 113b has a sequence number value of 125. Similarly, the PDU 113c has a sequence number value of 126. The PDU 113c, however, also utilizes a special length indicator (LI) 119. In order to enable the receiving side 120 to know that PDUs have been discarded by the transmission side 110 layer 2 interface 100 prior to transmission, the special LI 119 is used. The special LI 119 indicates that PDUs were discarded between the PDU 113b and the PDU 113c prior to transmission. A subsequent PDU 113d has a sequence number of 127. The encryption engine 106 on the transmission side 110 uses a hyper-frame number (HFN) 106h and the individual sequence numbers of the PDUs 113a-113d to encrypt the PDUs 113a-113d. Sequence number rollover occurs for the PDU 113e, and thus the HFN 106h is incremented. The PDU 113e uses the new HFN 106h for encryption, as do all subsequent PDUs 113. PDUs 113 were also discarded between PDUs

113h and 113i, and thus the PDU 113i utilizes the special LI 119 to indicate this.

The transmission side 110 transmits the PDUs 113 in the TTI 112 and the PDUs 113 are received in part by the receiving side 120, which generates received PDUs 123 for the reception-side TTI 122. The discarding method of the present invention may be utilized in either the MAC layer 104 or the RLC layer 102. For purposes of the present discussion, it is assumed that the present invention method is performed in the MAC layer 104. The reception-side 120 MAC layer 104 uses a previous sequence number value 104p to generate a starting sequence number value 104s. The highest expected sequence number value in the previous TTI 121 was a value of 123. That is, an ending sequence number value 104e for the previous TTI 121 held a value of 123. This value is incremented by one to obtain a value of 124 for the starting sequence number value 104s for the current TTI 122. The starting sequence number value 104s should thus be equal to the sequence number value of the first transmitted PDU 113a. The receiving side 120 MAC layer 104 knows that nine PDUs are to be received for the TTI 122, and uses this information to generate an ending sequence number value 104e. The ending sequence number value 104e is simply the starting sequence number value 104s plus the number of PDUs 123 expected in the TTI 122 minus one. For this example, then, the ending sequence number value is 124+9-1=4 (due to rollover of the 7-bit sequence number). The receiving side 120 MAC layer 104 will discard any received PDU 123 within the TTI 122 that does not have a sequence number that is sequentially within the bounds of the starting sequence number 104s and the ending sequence number 104e. Note that, due to the rollover of the sequence numbers, care must be taken to

properly determine whether or not a sequence number is within the acceptable bounds. For the example at hand, only sequence numbers within the set (124, 125, 126, 127, 0, 1, 2, 3, 4) are acceptable. All other sequence numbers for the received PDUs 123 result in a discarding of the associated PDU 123.

The first received PDU 123a has a sequence number value of 124, and so is accepted. The same holds true for the second and third PDUs 123b and 123c, respectively. The PDU 123c contains the special LI 119. The receiving side 120 thus knows that PDUs 113 were discarded by the transmitting side 110 between the received PDUs 123b and 123c, and behaves accordingly when assembling the PDUs 123 into corresponding SDUs. Although the transmitted PDU 113e is completely missed on the receiving side 120, the receiving side 120 can correctly infer sequence number roll-over from the sequence number values held within the PDUs 123d and 123f. Both the PDU 123d and the PDU 123f have sequence number values that land within the acceptable range, as defined by the starting sequence number value 104s and ending sequence number value 104e, and so are accepted. As the sequence number value of the PDU 123f is less than the sequence number value for the previous PDU 123d, rollover of the sequence numbers is inferred, and the HFN 106h on the receiving side is incremented accordingly. Decryption of the PDU 123f is thus successfully performed with the new HFN 106h value. Non-sequentiality between the sequence numbers for the PDUs 123d and 123f implies that the PDU 113e was lost in transmission, and the receiving side 120 may react accordingly when assembling the PDUs 123d and 123f into corresponding SDUs. A corrupted PDU 123g is also received within the TTI 122. The corrupted PDU 123g, however, does not have a sequence number that lands within the acceptable range. The corrupted PDU 123g

is thus discarded, and the HFN 106h on the receiver side is not modified. A subsequent PDU 123h is thus properly decrypted using a receiving side 120 HFN 106h value that is synchronized with the transmission side HFN 106h value. That is, the discarding of the corrupted PDU 123g prevents the transmission side 110 from becoming unsynchronized with the receiving side 120. A final received PDU 123i is thus also properly decrypted, as are all subsequent PDUs in a subsequent TTI 128.

Because the present invention uses a special LI 119 to indicate the transmission-side 110 discarding of PDUs 113, it is possible to ensure that the transmitted PDUs 113 all have sequence numbers that ascend without jumps or gaps. The receiving side 120 can use this information to discard any PDU 123 that is not within the expected range of sequence numbers for the current TTI 122. Additionally, as all PDUs 123 should have a proper sequential ordering, it is possible to discard any PDU 123 as corrupted that does not adhere to the sequential ordering of the previously received PDUs 123, even though the sequence number of the PDU 123 may be within the range of acceptable sequence numbers. For example, if the PDU 123h had a sequence number of two instead of three, the MAC layer 104 may still discard the PDU 123h as unacceptable as it is clear that the PDU 123h, based upon its position within the TTI 122, should have a sequence number value of three. This enables additional stringency on the acceptance of received PDUs 123.

In the above description, it should not be inferred that PDUs 113, 123, other than those with the special LI 119, have no LIs themselves. Quite the opposite is true. Every transmitted PDU 113 and received PDU 123 is capable of holding one or more LIs, as explained in the Description of the Prior Art. Such

LIs are necessary to properly reconstruct SDUs from the received PDUs 123. The above description simply indicates the novel LI 119 of the present invention, and ignores, for the sake of brevity, any other acceptable and possible LIs within the PDUs 113, 123. To better illustrate the LIs of the present invention, please refer to Fig.9. Fig.9 is a block diagram of an example PDU 130 according to the present invention. The PDU 130 uses a special LI 132a to indicate that PDUs immediately prior to the PDU 130 were discarded prior to transmission. The first octet of the PDU 130 includes a 7-bit sequence number (SN) field 131 and a single extension bit 133a. The extension bit 133a indicates the presence of a following LI, when set. In the preferred embodiment, the special LI 132a is the first LI in the PDU 130, and is a value that exceeds the maximum possible length of the PDU 130. Other positions of the special LI 132a are, of course, possible. The special LI 132a may be either 7 or 15 bits in length, and is followed by a single extension bit 133b to indicate the presence or absence of a following LI. The extension bit 133b is set to indicate the presence of a subsequent LI, LI_1 132b. LI_1 132b indicates the end of SDU_1 134b. As there are no more LIs in the example PDU 130, the extension bit 133c for LI_1 132b is cleared. The LI for SDU_2 134c will be found in a PDU that follows the PDU 130.

It is worth noting that the data in SDU_1 134b must be assumed to be the end of the data that was contained in the PDUs that were discarded on the transmission side prior to the PDU 130. Thus, the data in SDU_1 134b should also be discarded. Data from previously received PDUs may also have to be discarded, as it may mark the beginning of data that spans into the PDUs discarded on the transmission side. Re-assembly of PDUs into

SDUs is, consequently, not a straightforward task, and requires some care. Note that LI_1 132b might have a value of zero to indicate that no data is to be discarded from the PDU 130. Alternatively, two values may be utilized for the special LI 132a: The first value may indicate that data is to be discarded from the PDU 130, and the second value would indicate that no data is to be discarded from the PDU 130.

In contrast to the prior art, the present invention parses the sequence numbers of received PDUs within a TTI to ensure that the sequence numbers are all within an expected range for the TTI. Additionally, the present invention utilizes a special length indicator as a flag to signal that PDUs were discarded by the transmitter prior to transmission so that the receiver may properly reassemble received PDUs into SDUs. The use of this special LI enables a transmitter to transmit PDUs with smoothly incrementing sequence number values. The receiver can thus properly predict the expected range for the sequence numbers within the TTI. Additionally, as the sequence numbers smoothly ascend, the receiver can discard any PDU having a sequence number that does not conform to an expected value based upon the position of the PDU within the TTI.

Those skilled in the art will readily observe that numerous modifications and alterations of the device may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

CLAIMS

What is claimed is:

1. A method for determining acceptable ranges of received sequence numbers in a wireless communications protocol, the wireless communications protocol utilizing:

protocol data units (PDUs) for transmitting service data units (SDUs), each PDU comprising a sequence number of n bits for indicating a relative sequential ordering of the PDU in a transmitted or received stream of PDUs; and

a transmission time interval (TTI) in which a predetermined number of PDUs are transmitted or received;

the method comprising:

receiving a stream of PDUs within a TTI;

determining a starting sequence number and an ending sequence number for received PDUs within the TTI; and

discarding any received PDU within the TTI that has a sequence number that is sequentially before the starting sequence number or that is sequentially after the ending sequence number.

2. The method of claim 1 wherein the starting sequence number is obtained from an ending sequence number of a previous TTI.

3. The method of claim 2 wherein the ending sequence number of the previous TTI is incremented by one to obtain the starting sequence number.

4. The method of claim 1 wherein the ending sequence number is obtained by subtracting one from a result of adding the

number of PDUs within the TTI to the starting sequence number.

5. The method of claim 1 wherein the wireless communications protocol additionally utilizes a length indicator (LI) to indicate an ending position of an SDU within a PDU, and a special value is used for the LI to indicate that PDUs were discarded prior to transmission of the received PDUs.

6. The method of claim 5 wherein the special value for the LI enables transmission of sequence numbers in a manner that is predictable for a receiver so that the receiver may generate the starting sequence number and the ending sequence number.

7. The method of claim 6 wherein the sequence number of each and every successive PDU in the stream of PDUs is incremented by a fixed value.

8. The method of claim 7 wherein the fixed value is one.

9. A wireless communications system comprising:

a first station capable of transmitting a stream of protocol data units (PDUs) comprising a predetermined number of PDUs in a transmission time interval (TTI), each PDU comprising a sequence number of n bits for indicating a relative sequential ordering of the PDU in the stream of PDUs; and

a second station capable of receiving the stream of PDUs in the TTI, the second station utilizing:

a starting sequence number;

an ending sequence number; and

an interface for generating the starting sequence number and the ending sequence number, and for

discarding any received PDU within the TTI that has a sequence number that is sequentially before the starting sequence number or that is sequentially after the ending sequence number.

10. The wireless communications system of claim 9 wherein the interface utilizes an ending sequence number of a previous TTI to obtain the starting sequence number.

11. The wireless communications system of claim 10 wherein the interface increments the ending sequence number of the previous TTI by one to obtain the starting sequence number.

12. The wireless communications system of claim 9 wherein the interface obtains the ending sequence number by subtracting one from a result of adding the number of PDUs within the TTI to the starting sequence number.

13. The wireless communications system of claim 9 wherein the first station utilizes a length indicator (LI) with a special value to indicate that PDUs were discarded by the first station prior to transmission of the stream of PDUs.

14. The wireless communications system of claim 13 wherein the special value for the LI enables the first station to transmit the stream of PDUs with sequence numbers in a manner that is predictable for the second station so that the second station may generate the starting sequence number and the ending sequence number.

15. The wireless communications system of claim 14 wherein the sequence number of each and every successive PDU in the

stream of PDUs is incremented by a fixed value.

16. The wireless communications system of claim 15 wherein the fixed value is one.

ABSTRACT OF THE DISCLOSURE

A wireless communications protocol utilizes protocol data units (PDUs) for transmitting and receiving service data units (SDUs). Each PDU has a sequence number of n bits for indicating a relative sequential ordering of the PDU in a transmitted or received stream of PDUs. A transmission time interval (TTI) is also used in which a predetermined number of PDUs are transmitted or received. PDUs are received within a TTI. A starting sequence number and an ending sequence number for received PDUs within the TTI are found. Any received PDU within the TTI that has a sequence number that is sequentially before the starting sequence number or that is sequentially after the ending sequence number is discarded.

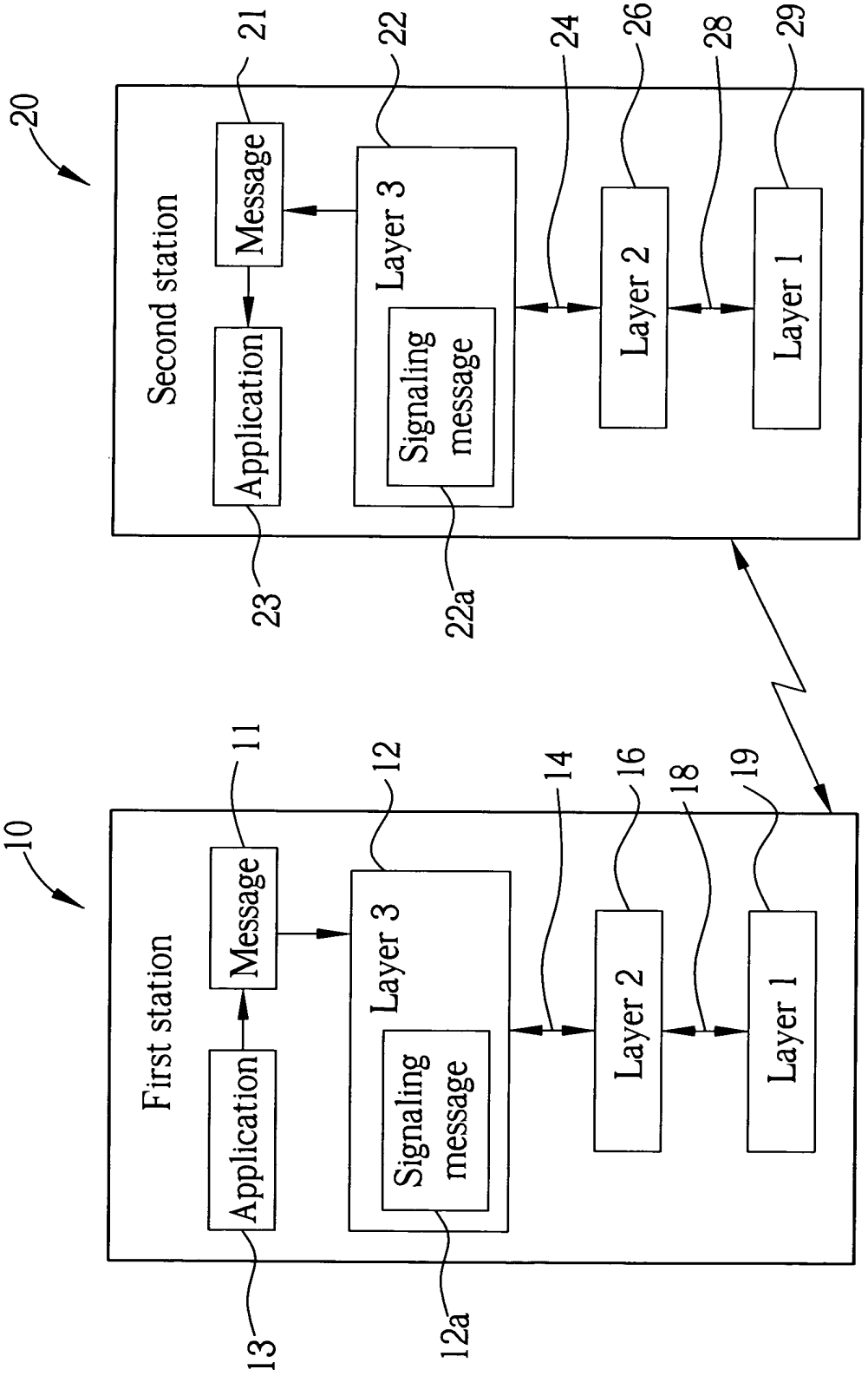


Fig. 1 Prior art

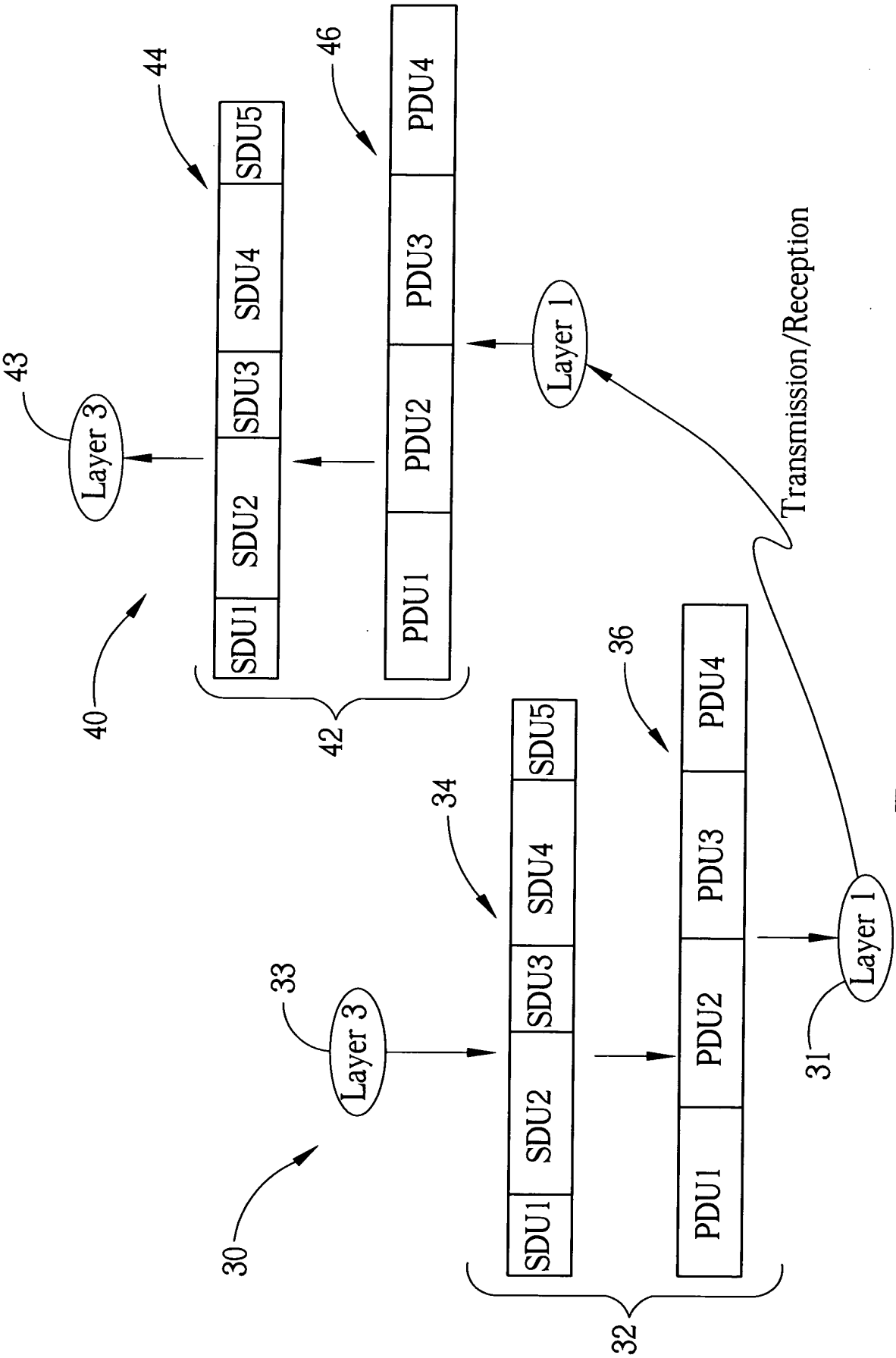


Fig. 2 Prior art

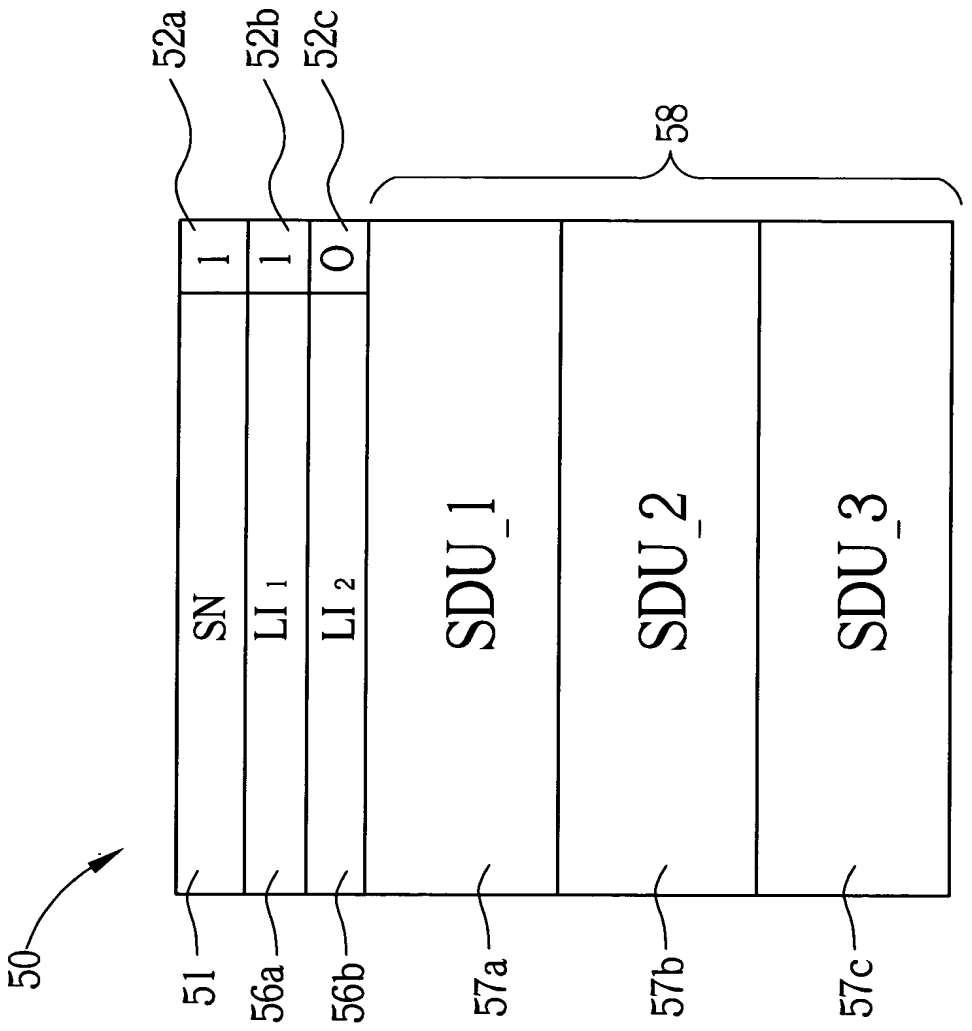


Fig. 3 Prior art

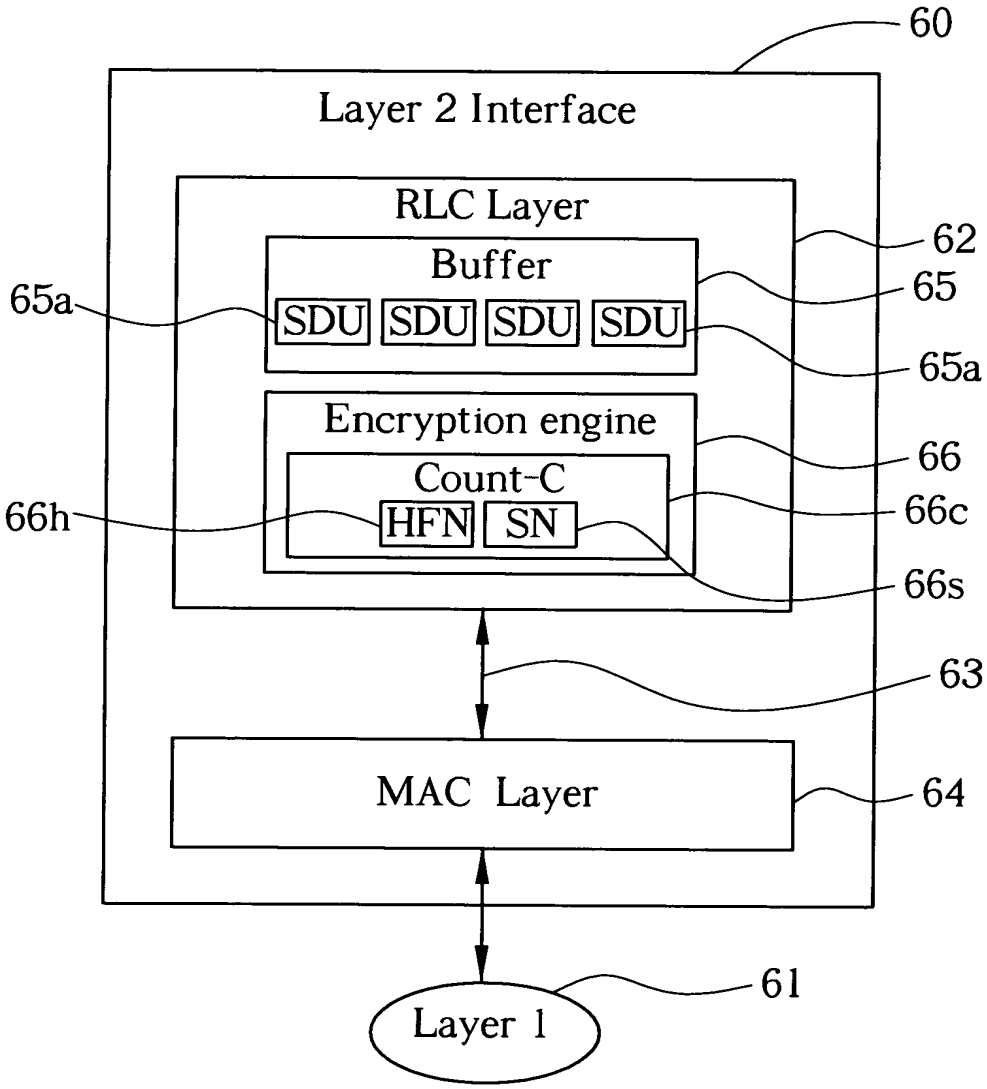


Fig. 4 Prior art

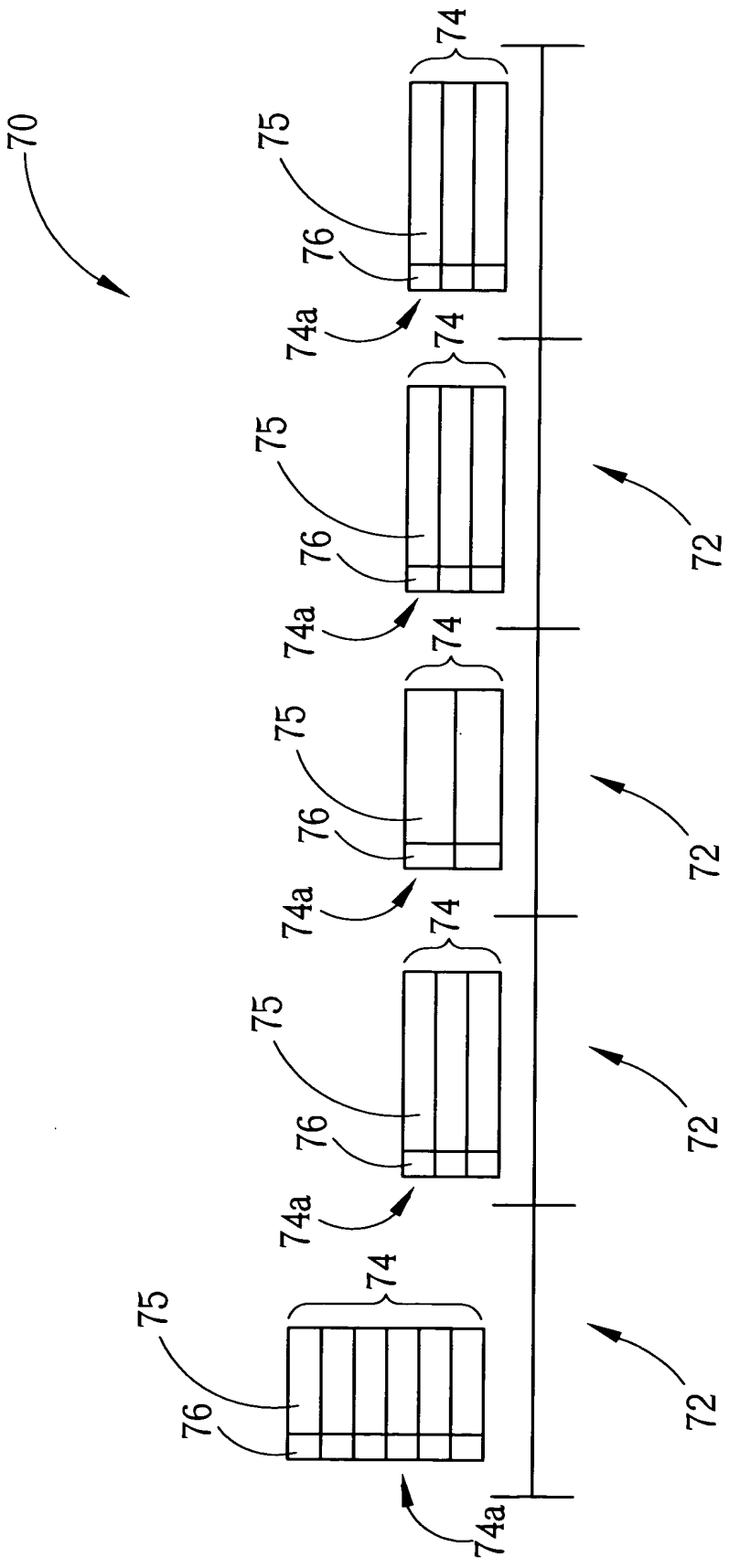


Fig. 5 Prior art

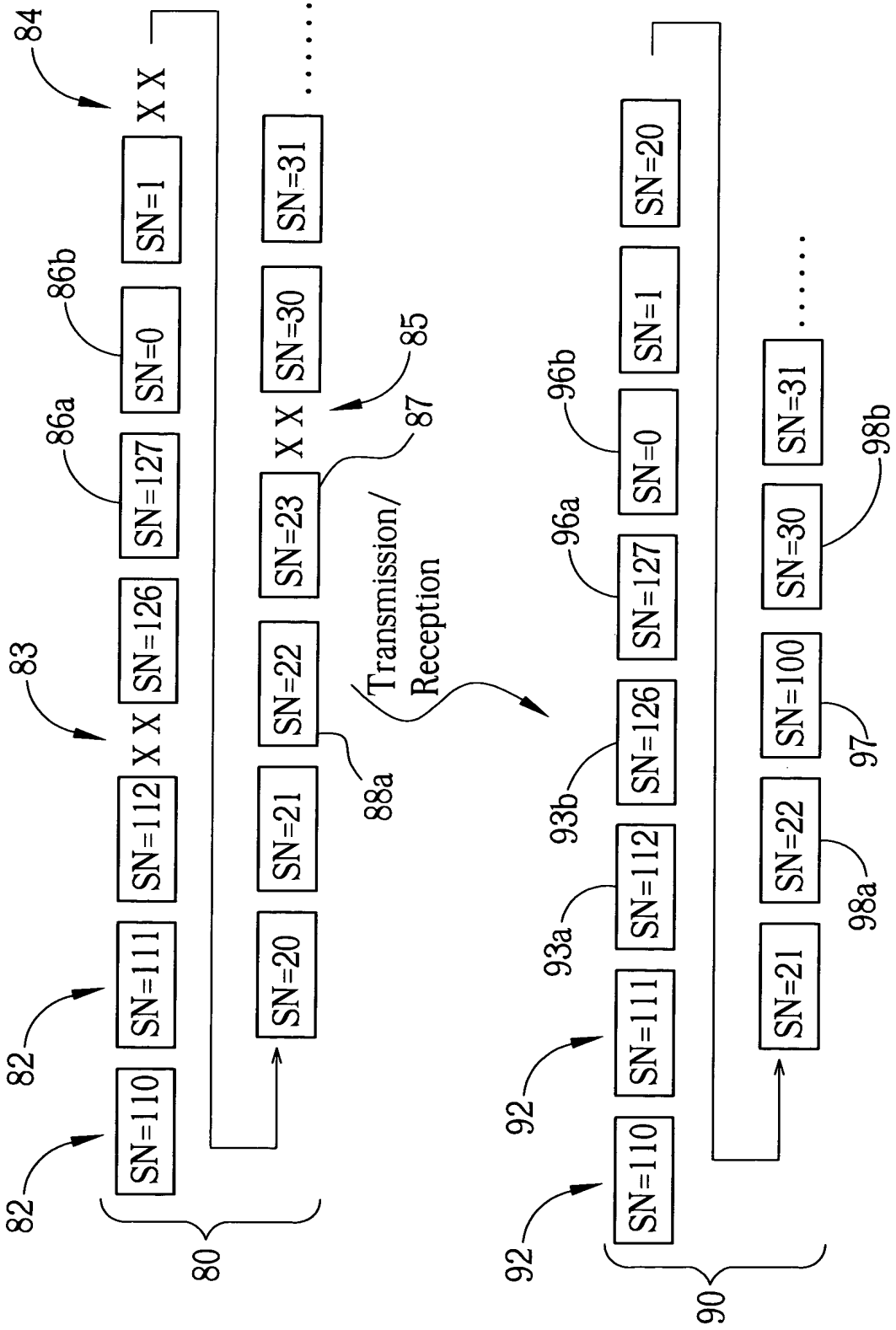


Fig. 6 Prior art

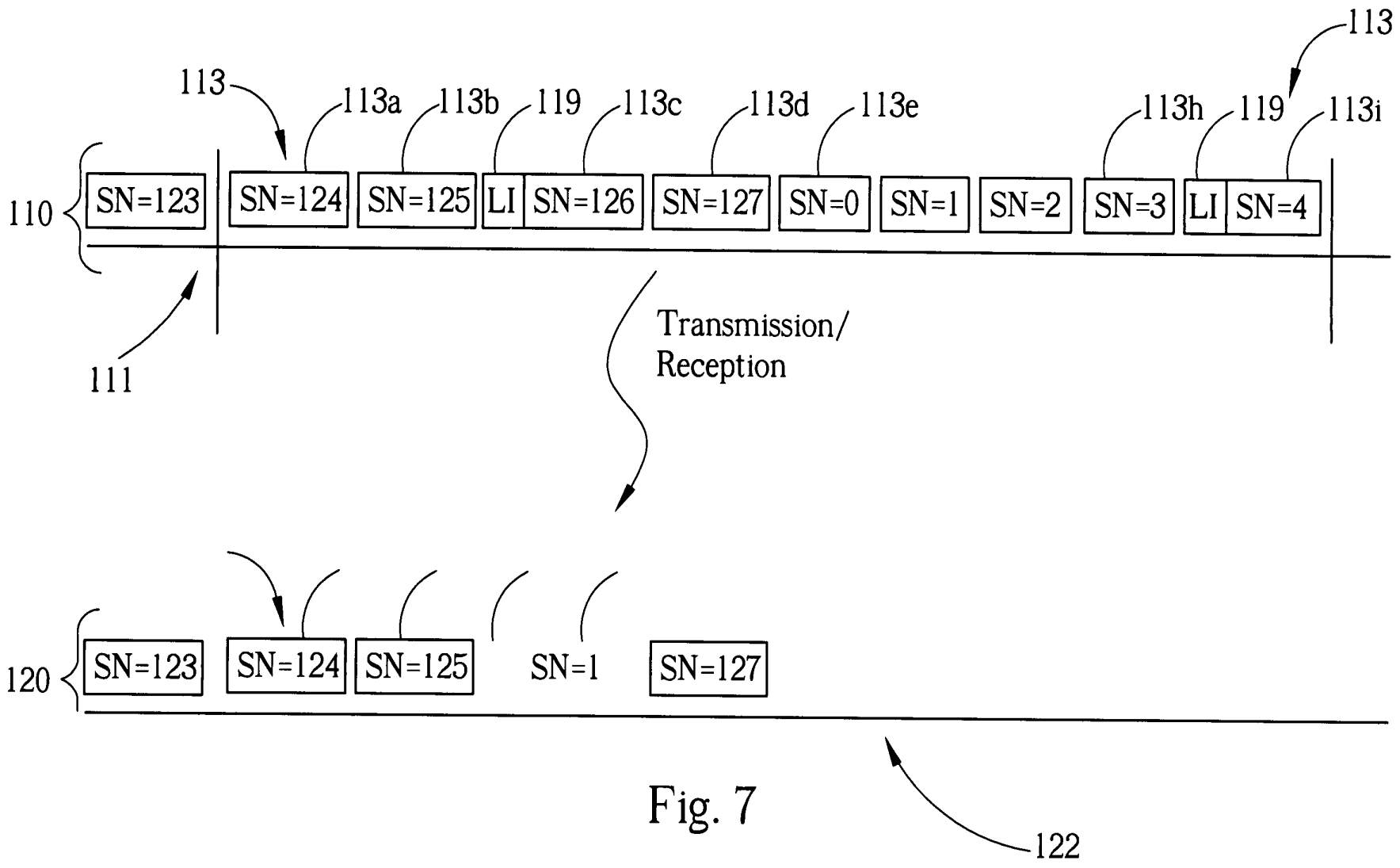


Fig. 7

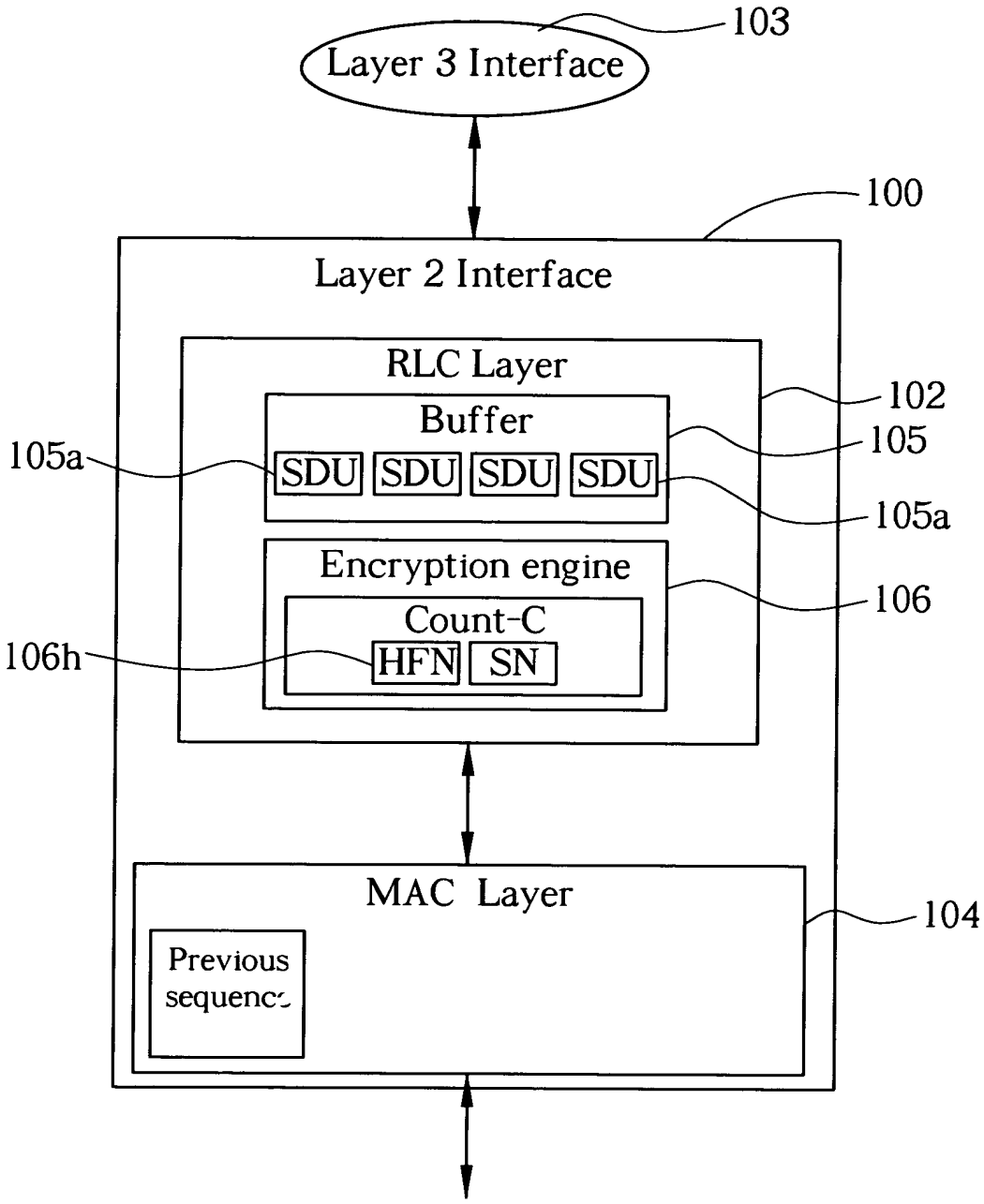
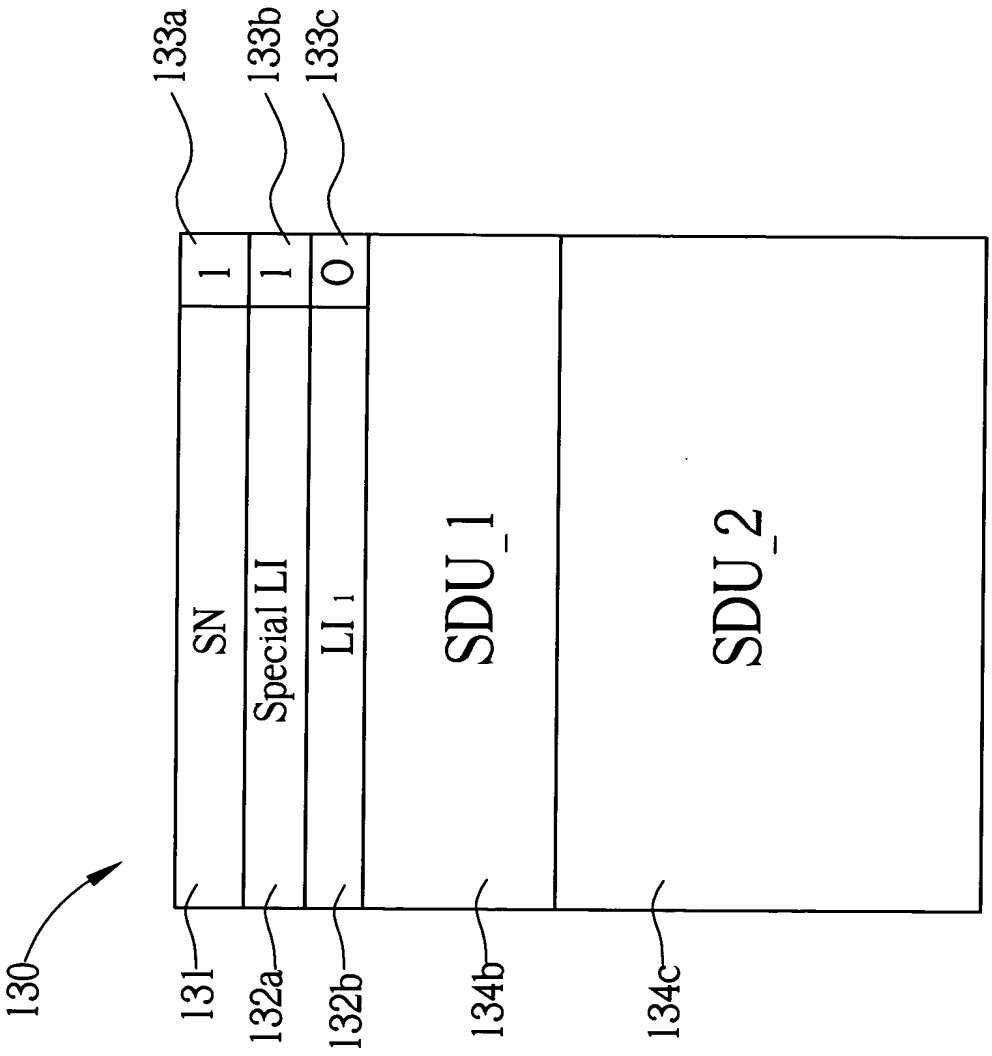

103
Layer 3 Interface
100
Layer 2 Interface
RLC Layer
102
Buffer
105
105a
SDU
SDU
SDU
SDU
105a
Encryption engine
106
Count-C
106h
HFN
SN
MAC Layer
104
Previous
sequenc

Fig. 8


130
131
132a
132b
134b
134c
133a
133b
133c
SN
Special LI
LI 1
SDU_1
SDU_2
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1
0

Fig. 9